

The Interaction of Cues to Phrasing and Cues to Lexical Stress in Greek

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Abstract

Research on the alignment of *F0* movements has shown that they align with the segmental string. This is the “segmental anchoring” hypothesis. In addition, research on the duration of segments at the edges of prosodic domains has shown that duration is a robust cue for the demarcation of prosodic levels, however, the exact operation of those cues under different conditions is still a matter of research. This paper addresses the question of how the alignment of *F0* of prenuclear pitch accents and the duration of segments in Prosodic Words of Greek might interact, when produced under different prosodic boundary and lexical stress placements.

We used Prosodic Words of the short “article + noun + clitic”, bearing an L*+H prenuclear pitch accent. From the results for the duration of the segments of the prosodic word we did not find support for mechanisms that have been found to operate on other languages, such as English and Dutch. The mechanisms examined were those of pre-boundary lengthening, polysyllabic shortening, accentual lengthening and articulatory strengthening. We found that the proclitic is shorter than the enclitic, which indicated a shortening of the proclitic. We also showed that the distance of the stress and pitch accent from the prosodic boundary causes a change on the duration of the segments of the noun of the prosodic word. That is, segments belonging to a word with stress further away from the boundary are longer than the ones with stress closer to the boundary.

Regarding the alignment of *F0* movements, we found that the Low tone aligns with the onset of the accented syllable, but is influenced by the existence of a word boundary. Surprisingly, we found that the H tone is not influenced by the existence of a prosodic boundary and aligns after the onset of the first postaccentual vowel, regardless of whether the clitic is a proclitic or an enclitic. Position of stress seemed to influence the alignment of the *F0* movements as well, since when the pitch accent lay further away from the prosodic boundary there was more time for the rise from L to H to take place.

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Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text. This work has not been submitted for any other degree or professional qualification except as specified.

(Evia Kainada)

To my parents, Elias and Polixeni.

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Chapter 1

Introduction and Background Work

1.1 Introduction

During the past decades there has been substantial work on prosody and the phonological analysis of intonation. The Autosegmental-Metrical Theory is a theory well established and it is the framework within which we will be working (theory first introduced by Pierrehumbert, 1980; revised by Beckman and Pierrehumbert, 1986; for a review and discussion see Ladd, 1996). This theory is based on the acceptance of the existence of two hierarchical structures; the *prosodic constituent structure* and the *rhythmic structure* (Selkirk, 1986).

The *prosodic constituent structure* implies that there is a hierarchical organisation of prosodic constituents which make up the utterances. These constituents are signalled by a variety of phonetic cues, such as the alignment and scaling of F_0 , the duration of segments at the edges of the prosodic domains, the use and length of pauses, the existence of connected speech phenomena etc. Although research has focused on investigating the exact ways in which each of those constituents can help in determining the different prosodic domains, there are still many questions unresolved.

In the past, research regarding F_0 and its use for the demarcation of prosodic domains was often based on assumptions that have been proved to be mistaken. For example,

one common mistaken assumption was that *F0* was an acoustic correlate of stress. Furthermore, the view that the beginning or the end of syntactic constituents is always signalled by a rise or a fall of *F0* (Cooper and Sorensen, 1981), has been shown to be too simplistic.

It is an acknowledged fact, though, that *F0* is not an acoustic correlate of stress, and that it is not used to signal *syntactic* constituents, although the prosodic constituents might co-occur with the syntactic ones. The Autosegmental-Metrical Theory has shown that *F0* is used to signal *pitch accents*, *phrase accents* and *boundary tones*. Pitch accents are

“...the phonological elements of the pitch contour that accompany certain stressed syllables” (Ladd, 1996, p. 45).

Usually there is a local minimum or maximum in *F0* that demarcates the pitch accent and the syllable with which the pitch accent is *associated*.

The association of the pitch accents with the segmental string has been a matter of debate. As Ladd (1996) notes:

“...a high *F0* peak is no longer seen as a phonetic property of a prominent syllable, but as an element of the phonological structure of the utterance, on a par with the prominent syllable itself” (Ladd, 1996, p. 55).

With this reasoning, it is considered of vital importance to see how this alignment of the *F0* movements of a pitch accent is regulated.

Aside to the research regarding *F0*, there has also been research regarding the durations of segments and how they relate to the existence of prosodic domains. In our experiment we will be investigating how *F0* alignment and duration of segments might interact, when involved in different possibilities of prosodic boundary and pitch accent placement.

During the introductory chapters of this paper we will (a) see what phrasing is, what cues signal it, how the alignment of pitch accents (and especially of prenuclear pitch accents) has been investigated, and the prosodic hierarchy that has been proposed for Greek, (b) we will review some of the literature on segmental durations and their rela-

tion to prosodic boundaries, and (c) we will see the relation of pitch accents to stress, and the cues that have been found to signal stress in general and in Greek.

Our motivation for this research is that, although there has been research on how durations work in the vicinity of prosodic boundaries and under different conditions of accent placements, as well as on how *F0* alignment anchors to specific points in the segmental string, there has not been a research that investigates how these cues might change their behavior under a manipulation of the prosodic boundary and pitch accent placement. We will come back to the motivation and goal of our paper in section 1.4.

1.2 Phrasing

Recent research on the phonological analysis of intonation has shown that speech is grouped into chunks. These chunks form their own hierarchy, which is different to the syntactic one. This is referred to as the *prosodic constituent structure*, or else the *prosodic hierarchy*. This hierarchy

“...is a structure of the same general sort that is familiar from syntactic description, one in which linguistic units are grouped into yet larger units, constituting a well-formed bracketing or tree” (Selkirk, 1986, p. 7).

There are still heated debates about which prosodic constituents form the prosodic hierarchy. Intonation and prosodic phrasing can group speech into chunks in ways that can either be similar to the syntactic structure, different from the syntactic structure, or even disambiguating for the syntactic structure. It has been acknowledged that both syntax “imposes some constraints on prosodic structure” (Shattuck-Hufnagel and Turk, 1996), and that intonational constituents are often used to mark differences between possible syntactic affiliations. For example, in the following utterances, the two syntactic possibilities can be distinguished with the use of different intonational phrases (placed within brackets):

{*When danger threatens*} your children call the police.

{*When danger threatens your children*} call the police. (Grabe, 2001)

These different possibilities of phrasing need to be signalled in the sound stream. As we already mentioned, there are several cues present for the speaker to use, such as the alignment of F_0 and the duration of segments. In the next two sections we will present how these two cues have been investigated in the past.

1.2.1 Pitch accents and alignment

In our experiment we are working with the alignment of the L and H tones of pre-nuclear pitch accents. There has been extensive research on the alignment of these tones, and it originally set out to investigate reasons that might interact with this alignment. Most of the research has focused on the alignment of the H tone, since the L tone has been found to have a regular alignment with the segmental string just before the onset of the accented syllable (Caspers and van Heuven (1993) for Dutch, Arvaniti and Ladd (1995) for Greek, Prieto et al. (1995) for Spanish etc.).

Some decades ago researchers noticed a “peak delay” of the alignment of the H and tried to investigate reasons that might cause it. Possible reasons were examined, such as pressure from an upcoming boundary (Silverman and Pierrehumbert, 1990), the existence of an immediately following pitch accent, and the effect of “time pressure” on the alignment of the H (Caspers and van Heuven, 1993).

The assumption that the alignment of the edge tones is regulated by “time pressure” has mostly been abandoned, though, since the finding of “segmental anchoring” (Arvaniti et al., 1998). Arvaniti et al. (1998) found that in Greek the alignment of the H is consistently aligned 10.6ms from the onset of the first postaccentual vowel. They also reported that “time pressure” only seemed to matter when there were no intervening unstressed syllables between two consequent pitch events. Only under these “extreme” conditions was the H alignment affected.

Following the research by Arvaniti et al. (1998) there have been many papers that investigate the “segmental anchoring” hypothesis under different perspectives. It has been shown that, for English, the alignment of the H remains anchored to a specific point in the segmental string even under different conditions of speech rate (Ladd et al.,

1999). Ladd et al. (2000) showed how the alignment of the H in Dutch is also conditioned by whether the vowel with which the alignment takes place is long or short. This means that, although there is no actual phonetic durational difference between the long and short vowel, the fact that the phonology of Dutch does distinguish between the two types causes a difference in the alignment of the H.

Regarding the constant alignment of the L tone, Ladd and Schepman (2003) have shown that the F_0 valley between two pitch accents is constantly anchored to the onset of the second accented syllable in English. They found that syllable boundary location has an effect on the alignment of the L in English. This research was taken up by Dilley et al. (2005), who elaborated on the alignment of the H tone of the accents that Ladd and Schepman (2003) had reported on, and added support to the existing evidence that the two tones of an L+H* are independently anchored to the segmental string and not with relation to one another.

However, one important finding that casts doubt on this “regularity” in the alignments that we have seen so far is the one presented by Atterer and Ladd (2004). They discovered that there is a difference in the exact temporal alignment of the H tone not only between languages, but even between varieties of the same language (Northern and Southern German). According to Ladd (2004) this suggests that there might be a difference in “phrasing” between different languages. ?)p.126]Ladd2004 state that

“we are not so much aligning specific targets at specific places in structure, but aligning whole movements relative to whole syllables”.

This suggests that there are language specific ways for the alignment of the Low and High tones of prenuclear accents. For example, German has been found to align its H tone later than even Greek does. This is a very interesting finding, and makes it worthwhile to look at how each language aligns its edge tones in order to see whether the suggestion of Atterer and Ladd (2004) for a continuum of alignments stands.

We can thus note that the exact operation of the association and alignment of pitch accents is not yet fully comprehended. Although there have been significant papers on the temporal alignment of F_0 movements and the regularities that exist within and/or across languages, it is becoming obvious that there are language specific phenomena,

which the theory has not yet been able to account for.

Our research is adding to the present research by investigating the alignment of the $F0$ movements under different positions of stress and phrasing. We aim to investigate how proximity to prosodic boundary and prosodic boundary placement influence the alignment of the Low and High tones of pitch accents and the duration of segments involved, as research so far has not addressed this question.

1.2.2 Duration

As we mentioned already, it is also the duration of the segments that signals differences in prosodic boundary placement. Furthermore, durational differences exist between stressed and unstressed, or pitch accented and non-pitch accented segments (or even between segments that lie in the vicinity of these). Our investigation for the duration of the segments of the prosodic words has two main purposes:

1. to find how and which durational mechanisms work under the conditions that we are investigating,
2. to make sure that the segmental make-up is not interfering with the results in the alignment that we are finding.

The manipulation of the duration of segments is regarded as one of the most robust cues to mark prosodic differences. Much research has been conducted on several languages, but the mechanisms operating are still far from being well understood. In this section we will present background work on the durational mechanisms that have been found to operate on several prosodic domains and on several languages.

Wightman et al. (1992) investigated how the duration of segments in the vicinity of prosodic phrase boundaries can help in distinguishing between prosodic levels. This mechanism is known as *pre-boundary lengthening*. Their research showed that, for English, it is the rhyme of the syllable before the prosodic boundary that gets lengthened. They were able to distinguish between four types of prosodic domains based on segmental durational differences. However, they did not report which prosodic

domains they thought were signalled by these durational differences were.

Apart from *pre-boundary lengthening*, several mechanisms have been reported to act at the edges of prosodic domains. These might operate on one prosodic level, but not on another. Some of these are *foot-lengthening*, *word-initial lengthening*, *insertion of pauses* etc. There has been significant research on several languages regarding these mechanisms.

Fougeron and Keating (1997) showed how phrase initial and final consonants manifest *articulatory strengthening*. Keating has shown how segmental durations are influenced by prosodic structure and their position in it (several papers, for an overview see Keating (2003)). Her research with her associates was extended to several languages, such as English, French, Japanese etc.

Turk and Shattuck-Hufnagel (2000) found support for the following mechanisms operating on the word level for English; *word-final lengthening*, *word-initial lengthening*, *polysyllabic shortening*, *syllable ratio equalisation*. Word-final lengthening was also reported by Beckman and Edwards (1990), who also found support for *phrase-final lengthening*, which, according to them, occurs at the edge of what they call intonational phrases.

One mechanism that we will be investigating in our data is one known as *polysyllabic shortening*. This mechanism was originally proposed by Lehiste (1972), who originally used this term to refer to the phenomenon of a stem's duration getting shorter as more syllables are added to its right. Further research on this phenomenon on English and other languages has shown that this is an asymmetric effect (has more of an effect on the syllables to the right of the stem than on the ones to the left) and it has also been reported that it only works within word boundaries.

Given that we are investigating the effect of pitch accents on the duration of the segments, we are also interested in the effect of *accentual lengthening*. This is another mechanism that has been investigated for several languages. Originally it had been reported that accentual lengthening was restricted on the (syntactic) word level (e.g. Sluijter and van Heuven (1996) for Dutch) and that the accented syllables were al-

ways longer than unaccented ones. Further work on English (Turk and White, 1999) and Dutch (Cambier-Langeveld, 1997; Cambier-Langeveld and Turk, 1999) has shown that accentual lengthening has an asymmetric effect on the syllables surrounding the accented one, meaning that there is a greater durational effect on the syllables to the right than to the ones on the left of the accented word. Furthermore, the word boundary does not block but rather attenuates the effect of accentual lengthening.

As we can see, the research concerning durational mechanisms has to answer several questions:

1. which durational mechanisms operate at prosodic boundaries?
2. in which level of prosodic hierarchy does each mechanism operate and in exactly what way?
3. what are the cross-linguistic differences and similarities in the behaviour of these mechanisms?

Having seen some of the work presented for other languages, we would like to now turn to Greek. Research regarding durational mechanisms at prosodic boundaries has only been indirect for Greek. Arvaniti (2000) has reported that she did not find support for *prosodic word final lengthening* in Greek, although this was not the focus of her research. This finding was also reported indirectly in Botinis (1989). Furthermore, Botinis et al. (2002) reported that final lengthening was not present in their data, although they do not report on the prosodic level they were working with. Moreover, they reported that there was an interaction between stress and syllable position in their data, but they did not go into more detail.

Research in Greek regarding these durational mechanisms has not been presented yet for either one of the questions we presented above. We will be obliged to draw assumptions for our experiment from research conducted on other languages. Our research will try to investigate the way segmental durations operate on the level of the prosodic word in Greek. We will see how the durations of segments change under different prosodic boundary and pitch accent placements.

1.2.3 Prosodic Hierarchy of Greek

The findings regarding the phonological organisation of intonation that have been presented by the Autosegmental-Metrical Theory have been adapted in a system for the transcription of intonation (the ToBI system = Tone and Break Indices). This is a system with practical purposes, which overlooks some problems of the theory. It is a system that has been applied to several languages, such as Spanish, Japanese etc. for the purpose of having a common ground for the transcription of intonation between transcribers.

Arvaniti and Baltazani (2005) have introduced the GRTToBI (Greek ToBI), which is the ToBI system applied to Greek. Although there is a substantial amount of research supporting this implementation of the system (Arvaniti and Ladd (1995); Arvaniti et al. (1998); Baltazani and Jun (1999); Pelekanou and Arvaniti (2001); Arvaniti (2001, 2002) among others), more research is in order so as to establish that the prosodic hierarchy of Greek is indeed the one they propose. Moreover, research is needed to identify the exact cues that signal each prosodic level in Greek.

Arvaniti and Baltazani (2005) propose that the Greek prosodic hierarchy constitutes of the following prosodic domains:

- Prosodic Word
- Intermediate Phrase
- Intonational Phrase

Since there is not enough research on Greek, we will follow the hierarchy proposed by them. The prosodic constituent that we will be working with is that of Prosodic Word, as we will present in the *Materials* section.

According to Arvaniti and Baltazani (2005), the Prosodic Word is allowed to carry only one stress, and thus at most one pitch accent. This condition can only be violated in the case of enclitic stress. In this case it is possible for the prosodic word to carry two stresses. In our experiment we will be working with a prosodic word that carries one stress. According to Arvaniti and Baltazani (2005) there are five pitch accents in

Greek:

- L+H*
- L*+H
- H*+L
- H*
- L*

We will focus on the prenuclear L*+H accent, which has been characterised as “the predominant choice for prenuclear accented syllables” (Arvaniti and Baltazani, 2005).

So far we have seen how phrasing has been found to be signalled by phonetic cues and how the alignment of the edge tones of pitch accents has been investigated. Our research involves the investigation of lexical stress as well. The reason for that will become transparent in the next section, where we will present the relation of the pitch accents to the lexical stress and the cues that have been found to demarcate stress.

1.3 Stress

Stress serves as the anchor point for pitch accents. Due to this fact, it has been a common misconception in the past that *F0* is the most important acoustic correlate of stress. Recent research has shown that this is not the case, and that fundamental frequency is the correlate of *accent* and not stress. Within the autosegmental metrical theory

“pitch accents are viewed in the first instance as building blocks of pitch contours, and stress is treated as a separate feature of the phonological organisation of utterances” (Ladd, 1996, p. 46).

It is also a well acknowledged fact that stressed syllables need not always be accented, while pitch accents do coincide with stressed syllables for some languages (such as English, French and Greek).

The experiment presented in this paper relies on the fact that stress and pitch accents coincide. We are going to manipulate the position of the stress, so as to move the pitch accent closer or further away from the prosodic boundary.

1.3.1 Cues to Stress

Although there has been a substantial amount of research on stress and its acoustic correlates, much of that research was based on the assumption that F_0 is a correlate of stress. Fry (1958) noted that pitch is what the listeners use to distinguish stressed syllables. He suggested that acoustic cues to stress are those of intensity and F_0 . This is a view that has been questioned by the AM theory, based on the fact that under different intonational patterns a stressed syllable may or may not carry a pitch accent. The AM theory assumes that

“‘pitch accent’ and ‘stress’ are...not the same thing” (Ladd, 1996, p. 47).

Beckman (1986) found that *total amplitude* “seems to be an exceedingly robust criterion for stress in English” (p. 177). She contrasted Japanese and English and found that for Japanese pitch change was the only cue to accent, while for English she found that other features hold a significant role, such as duration and total amplitude. This has been an influential work towards the notion that stress and pitch accent are distinct.

One important paper which incorporates this view is that by Sluijter and van Heuven (1996). They show that, if the pitch accent is controlled for, then the most important cues for stress in Dutch are *duration* and *spectral balance*, while *overall intensity* and *vowel quality* are not as important. The main acoustic cues that have been found to signal stress are *duration*, *amplitude*, *vowel quality* and *spectral balance*.

1.3.2 Stress in Greek

Greek is a language that has traditionally been described as *syllable-timed*. It has dynamic stress and each word can only bear one primary stress. The position of stress in each word cannot be predicted apart from the fact that the primary stress needs to

fall on one of the last three syllables of the word. This is known as the *Stress Well-Formedness Condition* (SWFC) (Arvaniti, 1992). Regarding our experiment it is also useful to note that clitics (either operating as proclitics or enclitics) do not have an inherent stress marking (Drachman and Malikouti-Drachman, 1999, p. 917).

Furthermore, stress in Greek is lexically distinctive, which means that one can find minimal pairs of words that can only be distinguished by the position of the stress in the word. In order to change the meaning of the word it is only the position of the stress that needs to be changed.

Regarding research on cues that signal stress for Greek, Botinis (1989) investigated the acoustic parameters of lexical stress, but he considered fundamental frequency as a cue to stress. He mentions that “the acoustic parameters of duration, frequency and intensity are referred to as primary cues to stress” (Botinis, 1989, p. 33). This gap in the research regarding cues to stress for Greek has been covered by Arvaniti (2000). She based her research on the distinction between stress and pitch accent. She mainly focused in *duration* and *amplitude* as the main acoustic cues for stress in Greek. Her conclusion was that *amplitude integral*, a measure that combines duration and amplitude, is the most robust cue for the perception of stress in Greek.

Although Arvaniti’s paper has presented a very good analysis of the cues that were investigated, it does not look at other possible correlates, which have been found to be important for other languages, such as *vowel quality* or *spectral tilt*. However, this is not a matter that will affect the investigation of our paper, since we are not examining these cues. Furthermore, since in our research we are interested to look at how cues of lexical stress interact with cues to phrasing, we are not interested in using *amplitude integral* as a cue to stress, but rather we will be looking at duration separately. Finally, at this stage of the investigation, we will not be looking at how *amplitude*, *spectral tilt* or *vowel quality* might change under the different conditions of our experiment. However, this should be considered a matter of further research.

1.4 Goal of the paper

As we saw in the Introductory sections, alignment of $F0$ movements and duration of segments are both phonetic cues that are considered as very robust for signalling prosodic domains. The goal of our paper is to examine how each of these cues might exhibit a different behaviour, when the conditions of prosodic boundary placement and stress (or else pitch accent) placement change. We anticipate that both the alignment of the $F0$ and the duration of the segments will be influenced by the place of the stress and by the proximity of a prosodic boundary. We also anticipate that different placements of prosodic boundaries will result in different alignments and durations for these conditions. In 2 we will present the the two-by-two design which we constructed, according to which we use a prosodic word bearing one prenuclear accent (L^*+H), where both the stress and the prosodic boundary change positions.

Chapter 2

Experimental Design

2.1 Materials

The materials consisted of prosodic words of the type “article + noun + clitic”. The nouns were minimal pairs of the form CVCV. Below we present how we manipulated the stress and phrasing conditions in our experimental design and how the prosodic words that we used were derived. We will present how the materials were presented to the participants and how the recordings were made. Finally we will show how we made the segmentations and the analyses.

2.1.1 Stress

Greek is a language with lexically distinctive stress; two words can have different meanings due to the difference in stress pattern. We used bisyllabic nouns, where the stress could be placed either on the first or the second syllable. All minimal pairs were made of nouns and are listed in table 2.1.

Stress 1	Meaning	Stress 2	Meaning
μέλι /'meli/	(the) honey	μέλι /me'li/	(of the colour of) honey
λάδι /'laði/	(the) oil	λάδι /la'ði/	(of the colour) of oil
ρόλος /'rolos/	part (in a play)	ρόλο /ro'lo/	(the) roll (for painting) (the) rolled roast
φίλη φίλοι	friend (female) friends (plural)	φιλή /fi'li/	(the) kiss (the) tribe
ράφι	(the) shelf	ραφή /ra'fi/	(the) stitch

Table 2.1: Minimal pairs used in the experiment

2.1.2 Phrasing

In our experiment we also wanted to manipulate prosodic phrasing, to investigate the change in the behaviour of cues under different prosodic boundary placements. We wanted to have the exact same segmental string with two different syntactic (and thus prosodic) possibilities. In Greek we can accomplish that with the use of the clitic.

The clitic /mu/ in Greek can either be a *proclitic* or an *enclitic*. In the same sequence of words it can have two distinct functions. Sentences 1 and 2 provide illustrative examples. The words that are marked with brackets form one prosodic word. In the first case the prosodic boundary lies after the /mu/ and the /mu/ acts as an enclitic, while in the second case the prosodic boundary is before the /mu/ and the /mu/ acts as a proclitic. Each example presents the sentence in Greek, a word-by-word translation, a full translation in English, and a transcription of the sentence.

1. /mu/ as an **enclitic** (=genitive)

{το μέλι μου} είναι γεμάτο ζουζούνια

(the honey my is filled bugs = my honey is filled with bugs)

/to 'meli mu 'ine γε'mato zu'zunia/

2. /mu/ as a **proclitic** (=dative)

{το μέλι} μου χαλάει τη γεύση του φαγητού

(the honey me spoils the taste of food = the honey spoils for me the taste of food)

/to 'meli mu xa'lai ti 'γε'fsi tu fa'ɣi'tu/

The design of the experiment creates four conditions that are directly comparable:

	Stress 1	Stress 2
Genitive	G1	G2
Dative	D1	D2

Table 2.2: Table for the four conditions of the two-by-two design and the names that we have given to each condition.

1. Stress on the first syllable and /mu/ as an enclitic (=genitive).
2. Stress on the first syllable and /mu/ as a proclitic (=dative).
3. Stress on the second syllable and /mu/ as an enclitic.
4. Stress on the second syllable and /mu/ as a proclitic.

From now on we will use a name for each condition. The two conditions of stress will be referred to with the numbers 1 and 2; 1 for the stress on the first syllable and 2 for the stress on the second. The two phrasing possibilities will be referred to with the use of the letters G and D; G for genitive phrasing and D for dative. The four conditions that are thus created for our two-by-two design can be seen in Table 2.2.

2.1.3 Embedding of sentences

Each minimal pair was used in four different sentences (one for each condition), which were in turn embedded into carrier paragraphs containing 4-6 sentences. The paragraphs served as distractors so that the participants would not be aware of the difference between the stress positions and the phrasing possibilities.

We used five minimal pairs, making a total of twenty sentences for all the conditions for all pairs. These were repeated by each participant three times. We used five filler paragraphs, which were meant to distract the participants from the make-up of the other paragraphs. Thus, the participants had to produce a total of seventy-five paragraphs ¹.

Prompts were designed in PowerPoint with the prosodic words in question always

¹A full list of the materials used can be found in Appendix I.

presented in the same line, so that there would be no delay or misunderstanding in reading due to the change between the lines. For example, if the /mu/ was affiliated to the noun as an enclitic, but was presented in a new line, this would be a case where the participant could get confused and make a mistake in reading. Furthermore, we took advantage of *syntactic priming* in cases where we thought that the participant could get confused as to where to affiliate the /mu/. Finally, we also made sure that the context of each paragraph within the same minimal-pair was be different, so that there was no semantic connection between paragraphs.

The length of the sentences used was approximately the same for all paragraphs, to avoid prosodic factors interfering with the results. We aimed at having as much as possible the same intonational patterns for all sentences.

2.1.4 Segmental make-up

Our main concern was to find minimal pairs with segments that would allow us to measure $F0$. Most nouns consisted of nasals, liquids and voiced fricatives. We did not use any voiceless stops but in two cases we used voiceless fricatives due to lack of minimal pairs that could be naturally produced in carrier sentences of the form that we wanted. Since these did not allow us to measure the alignment of the Low and High tones, we were obliged to make *ad hoc* decisions as to where we would place the Low and High tones.

Given that L has been found to align with the onset of the first accentual segment, or before that, in the cases where the first segment of the accented syllable was a voiceless fricative, we placed the Low at the onset of the fricative (see for example spectrogram 2.1, where the prosodic word /i 'fili mu/ is presented).

On the other hand, in the cases where the H coincided with the voiceless fricative, we placed the H right at the onset of the voicing after the fricative (which constituted the first postaccentual segment). We made this decision given that the H has been found to align within the first 10.6ms of the first postaccentual vowel. For example in figure

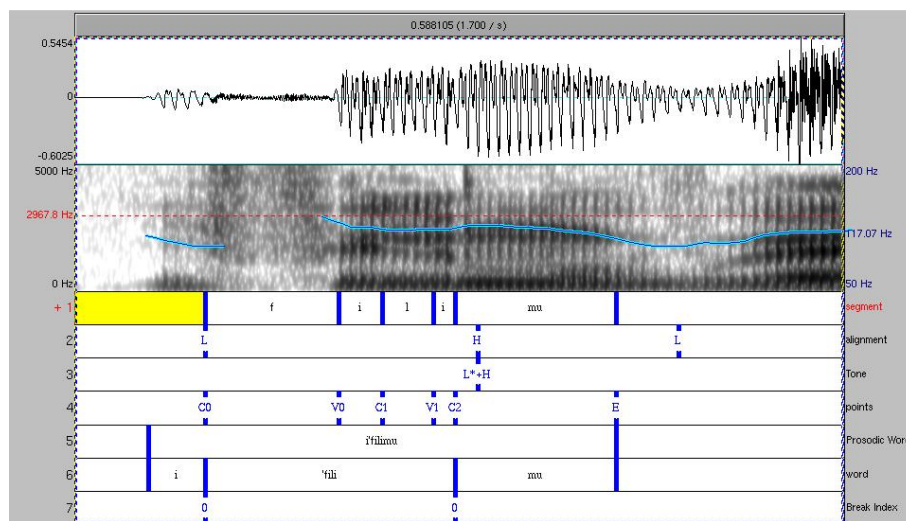


Figure 2.1: Spectrogram for the alignment of L, when an *ad hoc* decision was made due to the existence of a voiceless fricative (prosodic word presented: /i 'fili mu/).

2.2 we can see one example of the alignment of the H in the prosodic word /to 'rafi mu/.

We also took special consideration of the vowels that made up each word aiming to avoid vowels with different intrinsic durations and to make use of low or mid vowels. Though this was not always possible, /e/, /o/, /i/ and /a/ were used for the first syllable of the noun comprising the prosodic word, while four out of five minimal pairs ended with an /i/ and one ended with an /o/.

Some unwanted variation might arise from not controlling for the number of unstressed syllables following the prosodic word in question. Arvaniti et al. (1998) mention that ‘canonical’ alignment of the H tone requires “at least two unaccented syllables following the accented one, preferably within the same word as the accent”. There are cases in our data that do not follow this.

We also didn’t manipulate the segmental make-up of the verb following the prosodic word. This means that there were cases where the following verb contained voiceless stops or fricatives, making it difficult to locate the onset of the following Low tone. We followed the same reasoning as for the first Low.

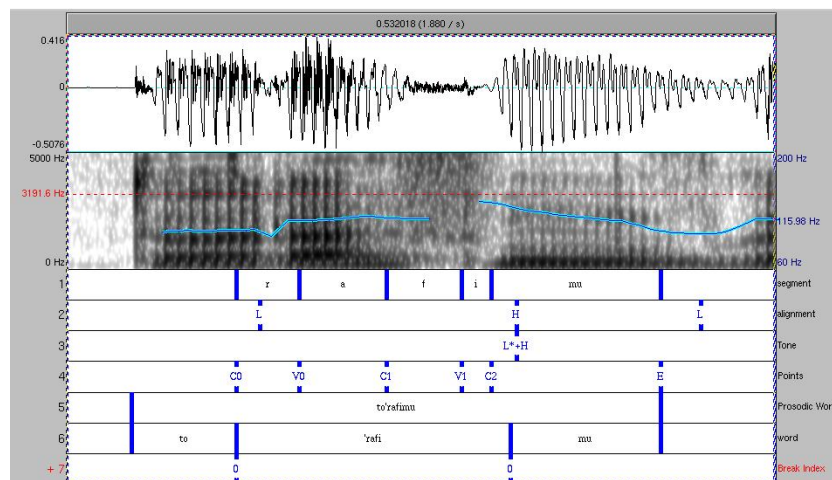


Figure 2.2: Spectrogram for the alignment of H, when an *ad hoc* decision was made, because it co-occurred with a voiceless fricative (prosodic word presented: /to 'rafi mu/.

These considerations in constructing the materials could only be controlled to a certain extent, given that it was very important to preserve naturalness in the sentences.

2.2 Recordings

The recordings took place in the recording booth of the University of Edinburgh, Department of Linguistics. They were made using an *AKG CK98 Hypercardoid microphone*, with a *MOTU 828 Mk2 Fireware* audio interface and with the *SONAR 4* studio edition editing software. All recordings were done as wavefiles at a sample rate of *48kHz* and *16bit* resolution.

The participants read the paragraphs from a PowerPoint presentation at their own pace. Each participant received a different PowerPoint presentation with different randomisation of the paragraphs.

2.2.1 Instructions to participants

The instructions, in Greek, were presented in the first two slides of the PowerPoint presentation. The main points were that they should read at their own pace and that they could rest whenever they wanted. Participants were allowed to scan through the paragraph before starting to read it, though none did. They were asked to try and follow the storyline in each paragraph and they were also told that if they made a mistake they should read that sentence again from the beginning. They were also asked to try not to move from their original position, to avoid changes in amplitude while recording ².

2.3 Speakers

Ten Greek participants, with the standard Athenian accent were recorded (four male and six female). They were all in their twenties and had been in the UK for a period of time from eight months up to four years. The participants were not paid for their help with the experiment.

2.3.1 Pre-test

The first available speaker was used as a pre-test. The participant had to produce paragraphs for seven minimal-pairs (7 minimal-pairs * 4 sentences for each minimal-pair * 2 repetitions=56 paragraphs). There were also seven filler paragraphs (7 filler paragraphs * 2 repetitions=14 paragraphs) totalling seventy (56+14=70) paragraphs overall. He had a problem producing two sentences from two minimal-pairs, since he didn't consider them natural. These minimal-pairs were discarded from our materials, leaving us with a total of five minimal pairs.

²Full instructions translated in English can be found in Appendix II.

2.3.2 Discarding of speakers and repetitions

We had to discard three speakers for the following reasons:

1. understanding the purpose of the experiment (speaker 1) - all participants were interviewed after the recording to test whether they had found the similarities in the sentences.
2. placing pauses in many sentences to mark the prosodic boundary (speaker 1, since she understood the purpose of the experiment, and speaker 3 - produced 14 out of 60 sentences with a pause)
3. not using the intonational pattern (L*+H) that we were looking for (speakers 3 and 6)
4. producing many sentences with disfluencies (speakers 3 and 6 had 6 and 8 sentences with disfluencies respectively).

During data analysis and segmentation of the remaining two males and three females we discarded sentences that:

- contained a different intonation pattern to the one we anticipated
- contained disfluencies.

This resulted in a loss of twenty-eight sentences out of a total of three hundred (9.3%).

In some cases, a connected speech phenomenon was observed between the noun and the clitic of the prosodic word, for example in the prosodic word /to 'ladi mu/, the segment /i/ was barely audible. We decided to keep those cases as examples of the smallest durational value that the segment can have. The surprising fact with this connected speech phenomenon was that it occurred both in genitive and in dative phrasing, which suggests that it was not influenced by the existence of prosodic word boundary.

2.4 Analyses

2.4.1 Segmentation

For the segmentation of the sentences we followed the proposal of Turk et al. (rev). The segmentation on the time axis was made by hand, using Praat, taking the waveform, the wide-band spectrogram and the *F0* tracks into consideration.

One segmentation issue that came up was that of the /r/. We segmented this by only regarding the friction part of the signal as /r/, and not the formant transitions, resulting in very small initial segments for these words.

We decided to segment the whole clitic as one segment, since in more than half the cases it was not possible to separate between the two segments. We were not sure whether it was an /m/ with the formants of the /u/, or whether it was a not fully articulated /u/. Therefore, the reference to which we would measure the H had to be adjusted, as presented below.

Low and High tonal targets were marked according to the following criteria:

- L was always marked as the last low point before the beginning of the rise
- H was always marked as the highest point of the rising tone

Figures 2.3 and 2.4 show cases of alignment of L and H tones for the two conditions of stress, when stress is on the first and second syllable respectively. The prosodic word being produced is /to meli mu/.

In cases where voiced fricatives or nasals were causing small microprosodic effects on the *F0*, we didn't compensate for those, but took the lowest point of the *F0* as the L point.

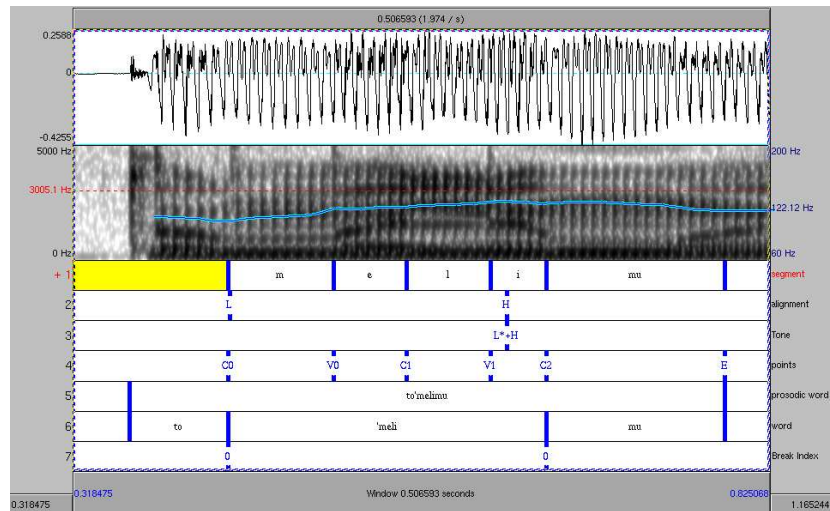


Figure 2.3: Spectrogram showing one example of the alignment of L and H, with stress on the first syllable.

2.4.2 Duration measurements

2.4.2.1 Segments

The duration measurements were made automatically with Praat scripts. Before performing the duration measurements, we set the onset of the first vowel of the noun as a zero point, from which all measurements would be taken (see figure 2.5).

In order to have V0 as the zero point in our axis, we performed the following calculations:

$$C0_{\text{point}} = C0 - V0$$

$$C1_{\text{point}} = C1 - V0$$

$$V1_{\text{point}} = V1 - V0$$

$$C2_{\text{point}} = C2 - V0$$

$$E_{\text{point}} = E - V0$$

Figure 2.5 also shows two other important points:

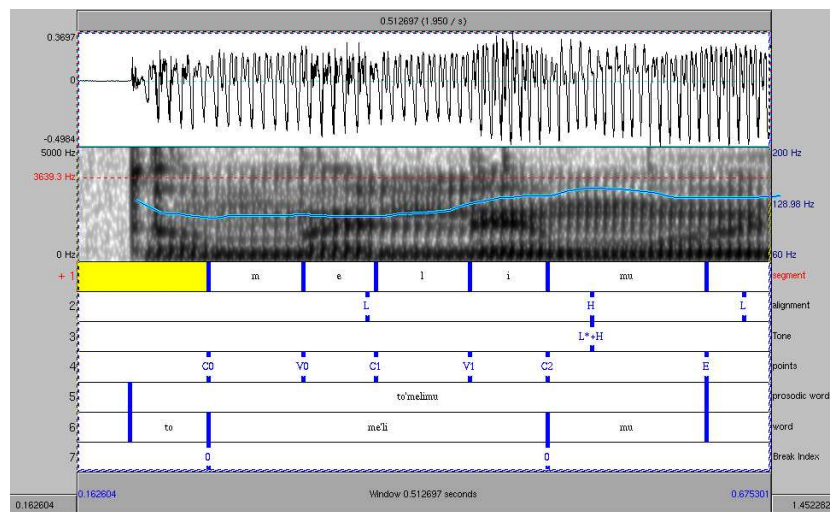


Figure 2.4: Spectrogram showing one example of the alignment of L and H, with stress on the second syllable.

1. Each of the five cells in our prosodic word corresponds to one segment (apart from the clitic):

C0 = the first consonant of the noun

V0 = the first vowel of the noun

C1 = the second consonant of the noun

V1 = the second vowel of the noun

C2 = the clitic

When referring, for example, to C2 as a segment, we mean the duration of the whole clitic.

2. We used the same names to refer to the segmental points that signal the onset of each segment, so, when referring to the segmental landmark C0, we do not mean the segment C0, but rather the point in time. Thus:

C0 = onset point of the first consonant of the noun

V0 = onset point of the first vowel of the noun

C1 = onset point of the second consonant of the noun

V1 = onset point of the second vowel of the noun

C2 = onset point of the clitic

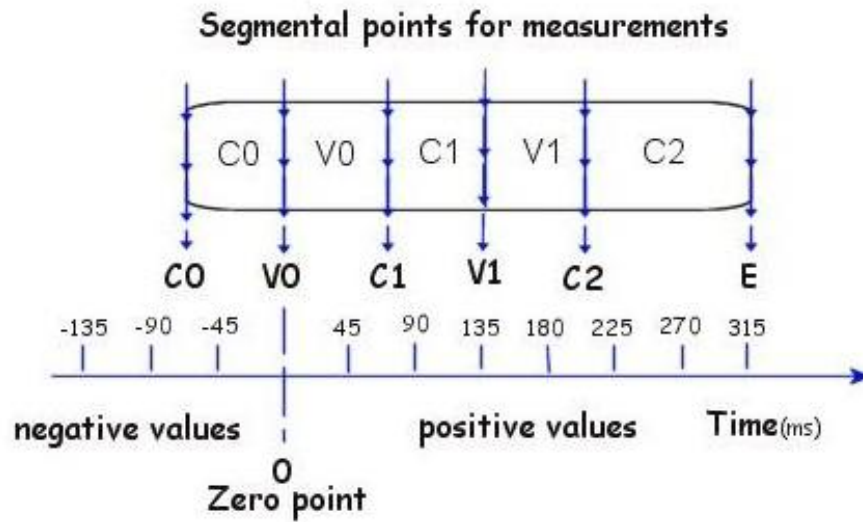


Figure 2.5: A figure illustrating segments, segmental points and V0 as the zero point in our time axis. All measurements in our experiment are made with reference to that segmental point.

E = offset point of the clitic

Thus, we calculated the duration for each segment in the following way:

$$C0dur = V0point - C0point$$

$$V0dur = C1\ point - V0point$$

$$C1dur = V1point - C1\ point$$

$$V1dur = C2point - V1\ point$$

$$C2dur = Epoint - C2point$$

2.4.2.2 Alignments

The same procedure was also followed for the L and H points. First they were measured with reference to V0, and then we calculated their distance from specific points of the segmental string. These were the following:

Stress on the first syllable:

$$L = L - C0$$

H = H-C2

Stress on the second syllable:

L = L-C1

H = H-E

We chose these segmental landmarks for the following reasons:

1. The L has been reported to always align with the onset of the accented syllable. Thus, we measured it: i) in the case with stress on the first syllable, relative to C0 (onset of accented syllable), and ii) in the case with stress on the second syllable, relative to C1.
2. The H is found to align after the onset of the first postaccentual vowel. Although we should measure its alignment with reference to the onset of the first postaccentual vowel, we measured it with reference to the first postaccentual consonant and not the vowel because we hadn't segmented the clitic into two segments, but as a whole. So we decided to measure the H with reference to the onset of the clitic in the cases with stress on the first syllable, and with reference to the offset of the clitic in the cases with stress on the second syllable.

In the next chapter we will present the results that we got regarding the behavior of the alignments and durations in the four conditions we are investigating.

Chapter 3

Results

The results will be presented in two blocks: first the results for the durations of the segments and then those for the alignment of the edge tones. The reason for this arrangement is that the results of the durations of the segments will be useful for the analysis of the alignment measurements.

Given our two-by-two design, we will be performing *two-way ANOVAs* for each analysis with STRESS and PHRASING as the repeated-measures factor (SPEAKER*PAIR*STRESS PHRASING). Stress has two levels: stress on the first syllable and stress on the second. Phrasing also has two levels: genitive and dative (enclitic and proclitic respectively).

In cases of interactions we will run *paired-samples t-tests*. For all the *t-tests* that we will be presenting, we assume that the null hypothesis is that there is no difference between the two variables examined on each occasion. If the result is significant ($p \leq 0.05$), then we are safe to reject the null hypothesis and assume that the two variables are significantly different. Otherwise, we cannot reject the null hypothesis.

3.1 Durations of segments

3.1.1 Hypotheses for the duration of the segments of the noun

The different conditions of stress and prosodic phrasing that we have in our experiment will cause differences in the duration of the segments that make-up our prosodic words. As far as the nouns that take part in the prosodic word is concerned, we can formulate the following hypotheses.

Regarding differences caused by different positions of stress, we expect that the segments belonging to a stressed syllable will be longer than the segments belonging to a non-stressed syllable. Fourakis (1986) reported that stressed vowels are longer than unstressed ones. Fourakis et al. (1999) showed that stressed segments were always longer in both focused and unfocused position. Moreover, Arvaniti (2000) investigated the phonetics of stress in Greek and reported that in minimal pairs of the short /'papa/ and /pa'pa/, both the consonant and the vowel belonging to the stressed syllable were longer than the ones belonging to the unstressed one.

We anticipate that there will also be an effect on the duration of the segments of the noun due to the different phrasing possibilities. The durational mechanism that could operate in our experiment is *pre-boundary* (or else *prosodic word final*) *lengthening*. Although there have been several mechanisms reported that might act at the word level, such as word-initial lengthening, polysyllabic shortening etc. (Turk and Shattuck-Hufnagel (2000), for an analysis on background work, see section 1.2.2), our data do not allow us to investigate anything else other than pre-boundary lengthening and polysyllabic shortening.

If we assume that Greek exhibits prosodic word final lengthening, then we expect that C1 and mainly V1 will be longer in the conditions with dative, than in the conditions with genitive ($D1 > G1$ and $D2 > G2$).

The second mechanism that we could investigate with our data is *polysyllabic shortening*. Polysyllabic shortening means that the word gets shorter as more syllables are added to it. It has been found to work for other languages, such like English, but has

not been investigated for Greek (see section 1.2.2). Should we assume that this mechanism works on the prosodic word level for Greek, we could assume that the prosodic word gets shorter the more syllables are added to it. This means that we could formulate the following hypothesis for our data; the noun in G1 and G2 should be shorter than the one in D1 and D2, since the prosodic word is smaller in the conditions with dative than in the conditions with genitive.

Finally, we also anticipate that segments belonging to stressed syllables will be longer than the ones belonging to unstressed ones. Thus, C0 and V0 will be longer in G1 and D1 than in G2 and D2, while C1 and V1 will be longer in G2 and D2 than in G1 and D1.

Before presenting the results for the durations of the segments of the noun, we would like to make a note. Although there have been several papers presented regarding durational behaviour in the vicinity of prosodic boundaries, there is still much that remains unanswered. In particular for Greek there have been no papers to our knowledge that investigate this kind of phenomena in depth. This is a factor that does not allow us to build hypotheses on already investigated and established conditions. For example, the assumption that we might find pre-boundary lengthening in the prosodic word level has not been established empirically yet for Greek. Furthermore, there has been no examination of polysyllabic shortening to our knowledge for Greek, so as to know if and at which level it operates.

3.1.2 Results for C0 and V0

3.1.2.1 C0

Table 3.1 presents the mean duration for C0. We can see that it looks like the consonant belonging to the stressed syllable is longer than the one belonging to the unstressed syllable only for the genitive condition and not for the dative.

The *two-way ANOVA* that we performed showed the following:

- *Stress* was found to be significant for the duration of the first consonant

C0	Stress 1	Stress 2
Genitive	64.6	56.5
Dative	59.3	59.1

Table 3.1: The mean in ms for the duration of the segment C0 in all four possible combinations.

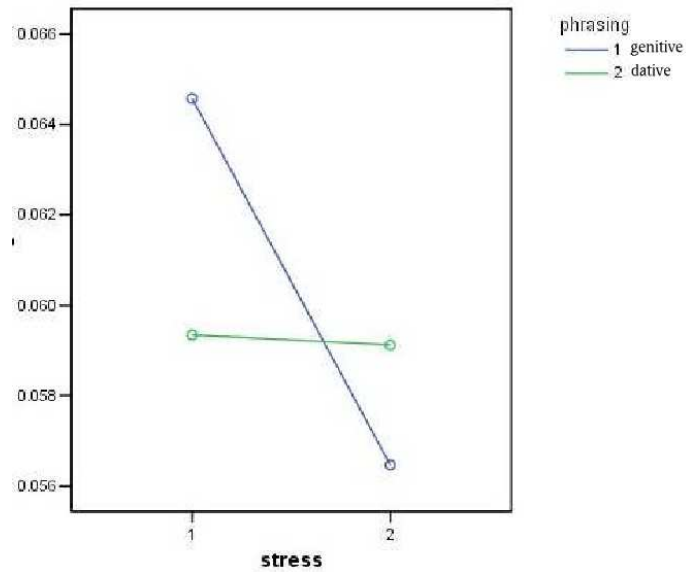


Figure 3.1: This figure shows the results for C0 for the *two-way ANOVA*, with *STRESS*PHRASING*.

$(F(5.455), df(1), p = 0.05)$.

- *Phrasing* was found to be non-significant ($F < 1$).
- Finally, there was a significant *interaction* between *stress* and *phrasing* ($F(7.773), df(1), p = 0.008$).

Figure 3.1 shows the interaction between *STRESS* and *PHRASING*.

We conducted *paired-samples t-tests* to find the exact reason for the interaction:

- *Stress* was found to be significant only for the condition with genitive ($t(3.906), df(57), p < 0.001$).

V0	Stress 1	Stress 2
Genitive	83.1	73.6
Dative	77.1	74.9

Table 3.2: The means in ms for the duration of the segment V0 in all four possible combinations.

- *Phrasing* on the other hand was only found to be significant for the condition with stress on the first syllable ($t(2.250)$, $df(62)$, $p = 0.028$).

At this point we should note that we expected a significant effect of stress for both phrasing conditions and not only for genitive. It is also interesting to keep in mind that when the stress is on the first syllable, segments in genitive are longer than in dative, although they are both stressed.

Post-Hoc Scheffé tests for SPEAKER and PAIR didn't show any differences between the speakers. There were significant differences in the duration of C0 for each pair. This is attributed to the fact that each pair consisted of different segments, which have different intrinsic durations.

3.1.2.2 V0

Table 3.2 shows the mean duration of V0 for each condition. Again there does not seem to be a difference between stressed and unstressed segments in the dative condition.

The *two-way ANOVA* for the V0 durations reported the following:

- *Stress* was found to be significant for the duration of the V0 ($(F(6.014)$, $df(1)$, $p = 0.018$).
- *Phrasing* on the other hand was not found to be significant for the duration of V0 ($F < 1$).
- Finally, we found a marginally non significant *interaction* between *stress* and *phrasing* ($F(3.617)$, $df(1)$, $p = 0.063$).

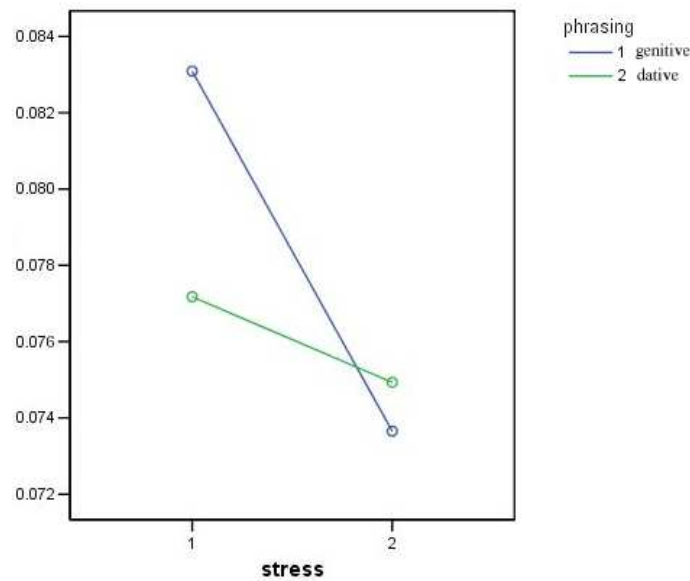


Figure 3.2: Figure for the results of the duration of V0 for the *two-way ANOVA* (STRESS*PHRASING). The y axis represents the durations in seconds.

Figure 3.2 shows the results in a diagram. It appears as though there is an interaction between the factors.

For that reason, and since there was a *marginally* non significant interaction, we decided to move on with the *t-tests*. These indicated that the marginal interaction came from the fact that while stressed vowels seem to be influenced by *phrasing*, unstressed ones do not (*t-test* for stressed vowels comparison between the two phrasing conditions: $t(2.927)$, $df(62)$, $p = 0.005$). It also came from the fact that only genitive is influenced by the place of stress (*t-test* for genitive comparison between two stress positions: $t(4.101)$, $df(57)$, $p < 0.001$), while dative is not.

There are two findings so far that we need to keep in mind:

1. It is not always the case that stressed segments are longer than the unstressed ones. Stressed segments were found to be longer than unstressed in the condition with genitive, but not in the condition with dative.

C1	Stress 1	Stress 2
Genitive	64.9	76.7
Dative	61.3	77.2

Table 3.3: The means in ms for the duration of C1.

2. Most importantly, segments in G1 were longer than D1, while segments in G2 were not longer than in D2.

3.1.3 Results for C1 and V1

3.1.3.1 C1

Segments C1 and V1 are the ones that make up the second syllable of the noun. Table 3.3 shows the mean duration of C1 for all conditions.

The *two-way ANOVA* gave us the following results:

- *Stress* was found to be significant for the duration of the C1 ($F(43.633)$, $df(1)$, $p < 0.001$).
- *Phrasing* on the other hand was not found to be significant for the duration of C1 ($F < 1$).
- Finally there was also no interaction between *stress* and *phrasing* for the duration of C1 ($F(1.064)$, $df(1)$, $p = 0.308$).

Figure 3.3 shows a graph with STRESS and PHRASING plotted against each other. This graph shows how segments belonging to the stressed syllable are longer than the unstressed ones. Furthermore, it shows that perhaps *phrasing* is important for the condition with stress on the first syllable (this was confirmed by *paired-samples t-test* ($t(2.089)$, $df(62)$, $p = 0.041$)).

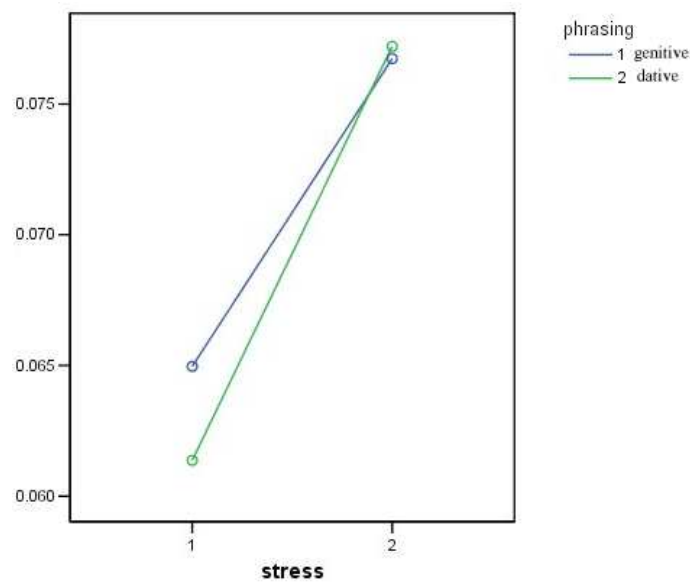


Figure 3.3: Figure for results of duration of C1 for the *two-way ANOVA*, (STRESS*PHRASING). The y axis represents the durations in seconds.

V1	Stress 1	Stress 2
Genitive	34.4	55.9
Dative	32.1	54.5

Table 3.4: The means in ms for the duration of V1.

3.1.3.2 V1

Table 3.4 shows the mean duration of V1 for all conditions.

The results from the *two-way ANOVA* reported the following:

- *Stress* was found to be highly significant for the duration of V1 ($F(94.53)$, $df(1)$, $p < 0.001$).
- *Phrasing* was found to be non significant ($F(3.332)$, $df(1)$, $p = 0.074$).
- Finally, we didn't find any interactions for stress and phrasing ($F < 1$).

Figure 3.4 shows STRESS and PHRASING plotted against each other. Stressed segments

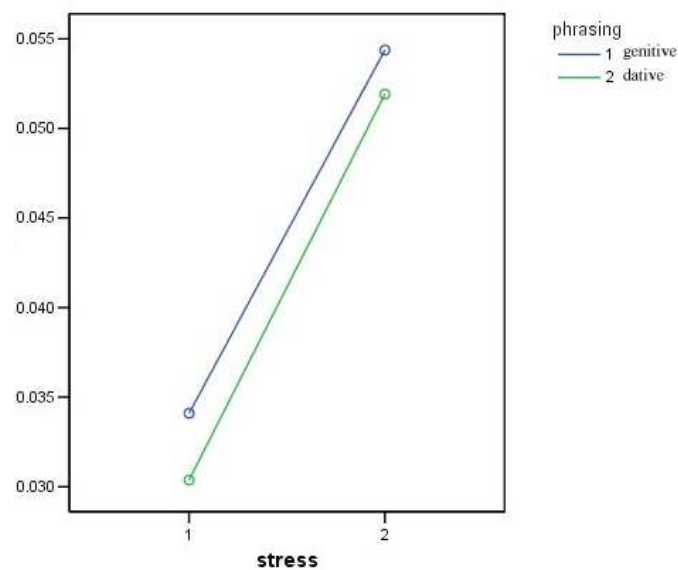


Figure 3.4: This figure shows the results for V1 for the *two-way ANOVA*, with STRESS*PHRASING.

are indeed longer than unstressed ones.

This is the exact same pattern with the one that we encountered for the segments of the first syllable. For example, in the case of /'meli mu/ the segment /m/ was significantly longer in the genitive than in the dative, when the stress is on the first syllable, while it is not when the stress is on the second.

Having presented the results for all the segments, we would like to return to the assumptions that we had made regarding the existence or not of polysyllabic shortening in Greek prosodic words. Our results indicate that this mechanism does not operate within the prosodic word of Greek. We expected to find longer nouns in the dative condition than in the genitive, while we found the exact opposite. We found that the nouns were longer in genitive than in dative for the conditions with stress on the first syllable, and they didn't have any difference for the conditions with stress on the second syllable. We will return to this mechanism in the section for the results of the clitic.

We also didn't find support for *pre-boundary lengthening*. We expected C1 and V1 to be longer in dative than in genitive, but we didn't find that pattern for any of the stress conditions. This is in accord with previous reported data, like those of Arvaniti (2000); Botinis (1989), who indirectly suggested that they didn't find this mechanism in their data.

One important difference was the one found between conditions G1, D1 and G2, D2. The noun in G1 was longer than in D1, while there was no difference between G2 and D2. This is due to the position of the stress in the prosodic word. The pressure from the upcoming boundary seems to cause this difference. In conditions G1 and D1 the durational differences can be fully produced since the prosodic boundary is further away, while in conditions G2 and D2 there is no time due to the boundary being closer.

Finally, we found that stressed segments are always significantly longer than the unstressed ones, with the exception of segments C0 and V0 between conditions D1 and D2. In that case there is no significant difference between stressed and unstressed segments.

3.1.4 Hypotheses for the duration of the clitic

The different conditions that our experiment is investigating will have an effect on the duration of the clitic as well. There are four mechanisms that might be operating for the duration of the clitic:

1. pre-boundary lengthening, or else prosodic word-final lengthening
2. accentual lengthening
3. prosodic domain initial strengthening
4. polysyllabic shortening.

Pre-boundary lengthening refers to the effect of prosodic boundaries on the duration of segments. As we mentioned in the introductory section, there is indirect evidence that Greek does not exhibit prosodic-word final lengthening. On the other hand, Tser-

danelis (2002) worked with prosodic words of the type that we are working with, and reported that the /u/ of the clitic proved to be a good indicator of the syntactic structure that it was being used in. He mentions that he finds a “clear influence of prosodic structure on segmental realizations” (Tserdanelis, 2002, p. 17). He found that the clitic in genitive is longer than in dative (although he does not provide statistical analyses for this finding). However, he does not report on other mechanisms that might be reliable for this finding, like for example the existence or not of accentual lengthening etc.

In our experiment we expect that if Greek does not exhibit prosodic word final lengthening, there should be no difference in the duration of the clitic between conditions G1 and D1, as well as between conditions G2 and D2. If, on the other hand, there is such a durational mechanism, then G1 should be longer than D1 and G2 longer than D2. Our analyses of C1 and V1 suggested that this mechanism does not operate in Greek.

Accentual lengthening refers to the lengthening of the duration of the syllable that bears the accent, as well as that of the duration of the adjacent syllables. It has been reported for Dutch that accentual lengthening occurs in all syllables in a word that are pitch accented (Sluijter and van Heuven, 1996). Significant research on accentual lengthening has also been presented by Cambier-Langeveld and Turk (1999) and by Turk and White (1999). Turk and White (1999) have shown that English exhibits accentual lengthening in pitch accented words. According to them, this mechanism is restricted to the word level, primarily the onset and nucleus of the syllable that bears the pitch accent. What is important for our experiment, though, is that they found a significant rightward effect on the duration of the syllable following the pitch accented one. They reported that this is an asymmetric effect; the syllable to the right is influenced more than that the one to the left. Turk and White (1999) report that, for English, the effect of accentual lengthening is attenuated and not blocked by the existence of a word boundary between the two syllables.

For the purposes of our experiment we would like to know whether the effect of accentual lengthening is attenuated or blocked by the existence of a prosodic boundary, such as that of a prosodic word. Since there has been no evidence to our knowledge regarding the effect of prosodic boundaries on accentual lengthening, we will make

hypotheses for all cases. We should also note here that no research has been conducted regarding these phenomena in Greek.

We are thus formulating two mutually exclusive hypotheses:

1. if accentual lengthening is attenuated and not blocked both by the existence of a prosodic word boundary and of an orthographic word boundary: we expect the clitic in G1 to be shorter than in G2 and in D1 to be shorter than in D2. We also expect that the clitic in G1 will not be different than in D1 (there is only a word boundary intervening), while in G2 it will be longer than in D2, since the prosodic boundary intervening only attenuates the effect of accentual lengthening.
2. if accentual lengthening is attenuated by orthographic word boundary, but blocked by prosodic word boundary: we are expecting the clitic in G1 to be shorter than in G2, but there will be no difference between D1 and D2. In this case also G1 will not be different than D1, but also G2 will not be different than D2, given the fact that the prosodic boundary blocks the effect of accentual lengthening.

We also consider the possibility of *articulatory strengthening* operating on the clitic. Fougeron and Keating (1997) found for American English that the effect of articulatory strengthening was greater at the beginning of a prosodic domain, than at the end. Should we suppose that the same occurs in Greek, we expect the clitic in the genitive to be shorter than the clitic in the dative, since the latter belongs to the beginning of a prosodic domain, while the former at the end of the prosodic word.

Finally, we are also investigating the effect of *polysyllabic shortening* on the clitic, as we did for the durations of the nouns. Supposing that this mechanism works within prosodic word boundaries for Greek, we expect the clitic to be longer in the conditions with dative than in the conditions with genitive, following the same reasoning that we had in the section with the nouns.

In the next section we will present the results for the duration of the clitic.

C2	Stress 1	Stress 2
Genitive	126.5	130
Dative	108	116.5

Table 3.5: The means in ms for the duration of the clitic.

3.1.5 Results for the Clitic (C2)

3.1.5.1 Results for C2

The mean durations of the /mu/ can be found in table 3.5. A first look at the means of the /mu/ gives the impression that the clitic in the genitive is generally longer than the one in the dative.

We conducted a *two-way ANOVA* and obtained the following results:

- *Stress* was found to be marginally non significant, ($F(3.656)$, $df(1)$, $p = 0.062$).
- *Phrasing* was found to be highly significant, ($F(20.603)$, $df(1)$, $p < 0.001$).
- Finally, we found no *interactions* between *stress* and *phrasing* ($F(0.940)$, $df(1)$, $p = 0.337$).

Figure 3.5 shows the fact that there are no interactions. We can see that the clitic is longer in genitive than in dative for both stress conditions.

The results that we got suggest the following:

- we did find support for *pre-boundary lengthening*, since the clitic in the genitive was significantly longer than the one in the dative for both stress conditions. We tend to discard this option, though, given the fact that we did not find support for this mechanism in the duration of V1, which should also exhibit prosodic-word final lengthening.
- we did not find support for *accentual lengthening*. The main finding that would be in support for accentual lengthening would be to have a clitic longer in G2 than in G1 (since in G2 it is closer to the pitch accent and there is also no prosodic

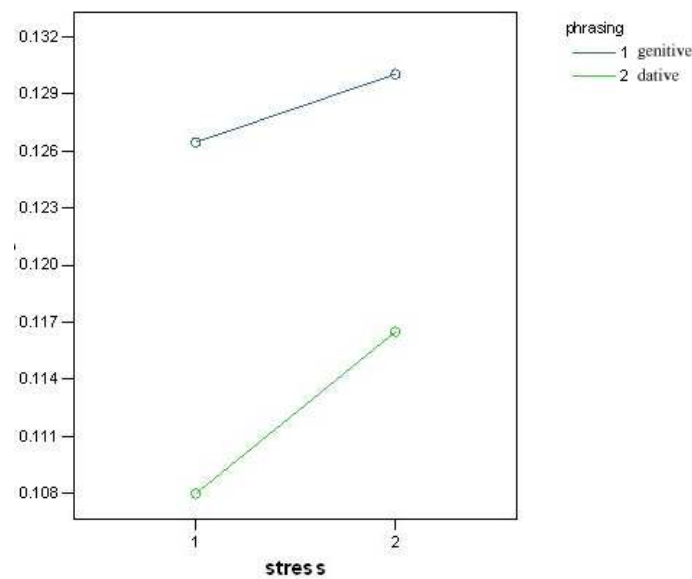


Figure 3.5: This figure shows the results for C2 for the *two-way ANOVA* (STRESS*PHRASING).

boundary intervening), but this was not what we found. We also expected that the clitic would not be different between conditions G1 and D1, which was not the case.

- we did not find support for *phrase initial articulatory strengthening*. For this mechanism we expected dative to be longer than genitive, which is exactly the opposite from what we found.
- finally, we also did not find support for *polysyllabic shortening*. The clitic was longer in the conditions with genitive than in the conditions with dative, which is the exact opposite of what this mechanism would predict.

The durational patterns that we get from the clitic are somewhat complicated. The main effect that we found was that the clitic was longer in the genitive than in the dative for both stress conditions. Given that we did not find support for preboundary lengthening, we think that the proclitic gets shortened in comparison to the clitic.

Regarding the behaviour of the clitic in our experiment, we would like to make one

final note. We have found that the first segment of the clitic (i.e. /m/) undergoes a change that could be attributed to a connected speech phenomenon. By that we mean that occasionally the /m/ is not fully articulated. It has been reported by many studies, and especially for English, that monosyllabic function words can exhibit modification of their initial segments, like the modification of *going to* to *gonna* (Turk and Shattuck-Hufnagel, 2000). This connected speech process could be operating as a cue for the speakers to distinguish between prosodic phrasings. This is a question that has not been addressed by our experiment and needs further investigation. Given the fact, though, that we found this phenomenon for both phrasing conditions, we tend to believe that it is not used to mark the different prosodic phrasings, but still our results are not reliable enough to let us draw any safe conclusions.

3.1.6 Conclusions for the durations of segments

The general trends that we have found regarding our data are the following:

1. We did not find support for *pre-boundary lengthening*, *accentual lengthening*, *polysyllabic shortening*, or *articulatory strengthening* in our data.
2. Stressed segments were found to always be longer than unstressed ones with the exception of C0 and V0 where the stressed segments were not longer than the unstressed ones between conditions D1 and D2.
3. The clitic tends to be shortened when it is affiliated as a proclitic than as an enclitic.
4. Finally, we found that all segments of the nouns were longer in G1 than in D1, but they were not significantly different in G2 and D2. This is an interesting finding that might suggest that the proximity of the stress to the boundary influences the duration of the segments. When stress is further away there is no pressure from the boundary and thus the durational differences take place, while there is a prosodic boundary nearby, the durational differences are oppressed.

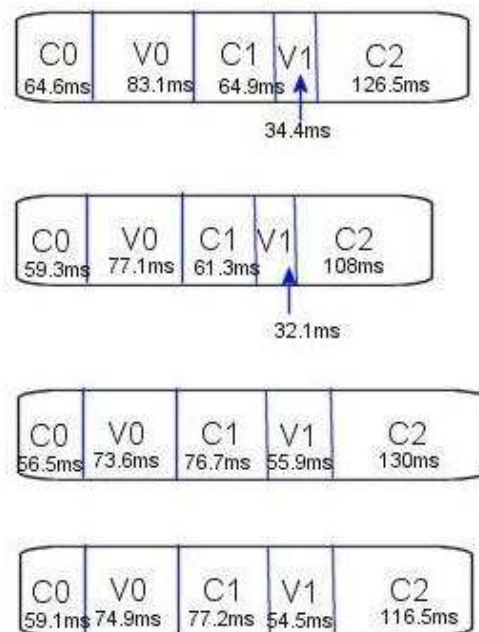


Figure 3.6: This figure shows the mean durations in ms of all segments of the prosodic word for all conditions. The first table is condition G1, the second D1, the third G2 and the fourth D2.

Figure 3.6 shows the durations of all the segments for each of the four conditions, so that the reader will be able to visualise the differences. The first table is condition G1, the second D1, the third G2 and the fourth D2.

3.2 Alignment of Low and High tones

3.2.1 L alignment

There has been extended investigation on the alignment of the L*+H prenuclear tone. As we presented in the Introduction, for Greek as for many other languages, the alignment of the L has been found to be very stable with reference to the segmental string, occurring approximately 5ms before the onset of the pitch accented syllable (Arvan-

L	Stress 1	Stress 2
Genitive	5.1	-3.2
Dative	5.9	-3.4

Table 3.6: The means in ms for the alignment of the L.

iti and Ladd, 1995). We do not anticipate that the stress or phrasing should have any influence on the way that the L will be aligned with reference to the segmental string.

3.2.1.1 Results

The results did not differ very much from the ones we anticipated. Table 3.6 presents the mean alignment of the L for each of the four conditions.

We first ran a *two-way ANOVA*, to see whether the conditions of *stress* and *phrasing* were significant and whether there were any interactions between them. The results that we got were the following:

- *Stress* appeared to be marginally significant for the alignment of the L ($F(4.128)$, $df(1)$, $p = 0.048$).
- *Phrasing* on the other hand was not significant ($F < 1$).
- There was no interaction between the two factors ($F < 1$).

Figure 3.7 represents the effect of *stress* and *phrasing* on the alignment of the L. We would like to remind the reader that the L in the condition with the stress on the first syllable was measured relatively to C0 segmental landmark, while in the condition with the stress on the second syllable it was measured relatively to C1. Any negative values indicate that the L was aligned earlier than the onset of the consonant to which it was compared. We can see that there is a difference in the alignment of the L between stress conditions for both phrasings.

Thus, one interesting finding from these results was that there was a difference for the alignment of the L between the two stress conditions. This was against our original

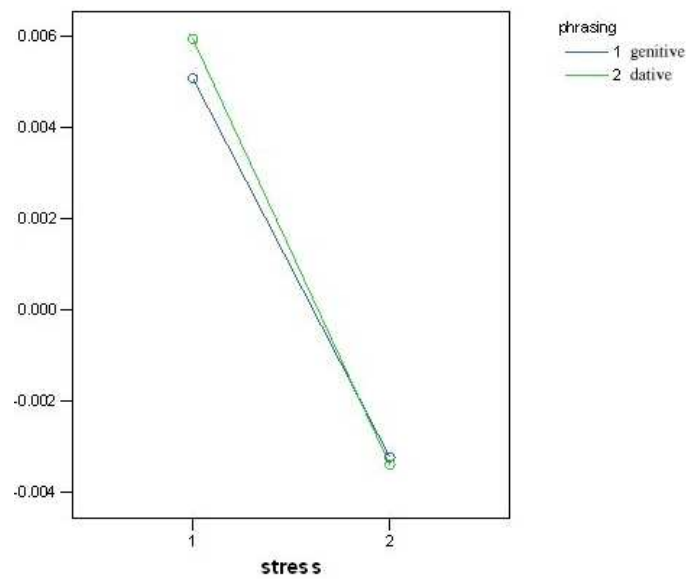


Figure 3.7: This figure shows the results for the alignment of the L for the *two-way ANOVA* (STRESS*PHRASING). Any negative values indicate that the L is aligned prior to the segment to which it was calculated. The y axis represents the durations in seconds.

predictions. When the stress was on the first syllable, the alignment of the L occurred 5-6ms after the boundary of the first accentual consonant. On the other hand, when the stress was on the second syllable, there was a ‘canonical’ alignment, as the one reported by other papers. The L was aligned approximately 3-3.5ms before the onset of the first accentual consonant. This difference might be due to the fact that there is a word boundary in the case of stress on the first syllable, while there is none in the case with stress on the second syllable. We are thus finding a left word boundary effect on the alignment of the Low. This suggests that there is a left word boundary effect on the alignment of the Low.

3.2.2 H alignment

3.2.2.1 Hypotheses for the alignment of the H

The alignment of the High tone is expected to differ in each of the four conditions that we are investigating. As mentioned, Arvaniti et al. (1998) found that the alignment of the H lies 10.6ms from the onset of the first postaccentual vowel. Taking this into consideration we can formulate the following hypotheses:

- we expect a difference in the alignment of the H caused by the different placement of the boundary. In the case where the boundary is in dative, we expect the alignment to be placed earlier than in genitive. The boundary will exercise pressure on the rise for the pitch accent and thus there will be an earlier alignment. This means that the H in D1 and D2 will be aligned earlier than in G1 and G2.
- the difference in stress position results in a difference of pitch accent position. In the cases with stress on the second syllable, the pitch accent lies closer to the prosodic boundary, than in the cases with stress on the first syllable. This means that the effect of pressure from the boundary should be more evident in the cases with dative. In particular for the case D2 (e.g. /to me'li # mu/), we expect the pressure from the boundary to be greater. The speaker will have to make a choice between taking the boundary into consideration and placing the H alignment before it, even though the “canonical” alignment would be within the first postaccentual vowel (i.e. the /u/ of the clitic in this case), or to ignore the boundary and place the alignment within the first postaccentual vowel.

3.2.2.2 Results

Table 3.7 shows the means for the alignment of the H for all conditions. We need to remind the reader that, in the case of the stress falling on the first syllable, we measured the alignment with relevance to the C2 landmark (which is the onset of the clitic). In the condition with the stress on the second syllable we measured the alignment with reference to the landmark E (which is the offset of the clitic). The negative values

H	Stress 1	Stress 2
Genitive	-4.3	-99.6
Dative	-12.8	-77.6

Table 3.7: The means in ms for the alignment of the H. The negative values indicate that the alignment lies before the segmental landmark with reference to which we calculated the H alignment.

indicate that the H is aligned earlier than the segmental landmark to which it was measured.

One note regarding the mean alignments of the H is that it does not seem to be aligned approximately 10ms from the onset of the postaccentual vowel. The H is aligned approximately 4ms before the onset of C2 in condition G1 and 12ms in condition D1. Since the duration of V1 (the first postaccentual vowel) was 34ms and 30ms respectively for each condition, the alignment of the H in G1 lies 30ms after the onset of the first postaccentual vowel, and 18ms for the condition D1. This is at odds with what Arvaniti et al. (1998) found.

Unfortunately, we are not in a position to calculate the exact position of the H for the conditions G2 and D2 (/to me'li mu#/ and /to me'li # mu/), since we measured it with reference to the end of the /mu/ and we haven't got measurements for the duration of the /u/ separated from the /m/.

In order to analyse our data, we performed a *two-way ANOVA*. The results are the following:

- *Stress* appears to be highly significant for the alignment of the H ($F(256.41)$, $df(1)$, $p < 0.001$).
- *Phrasing* appears to be marginally non significant ($F(3.234)$, $df(1)$, $p = 0.079$).
- There was a significant *interaction* between stress and phrasing ($F(8.886)$, $df(1)$, $p = 0.005$).

In order to indicate the exact source of this interaction we performed *paired-samples*

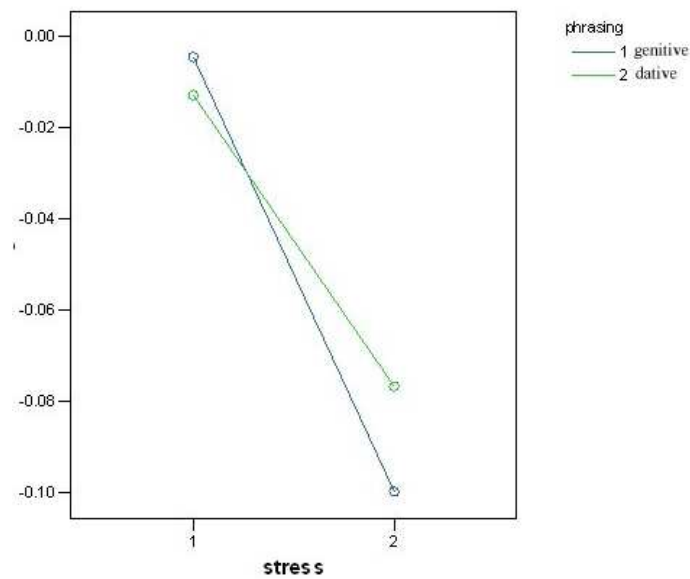


Figure 3.8: This figure shows the results for the alignment of the H for the *two-way ANOVA* (STRESS*PHRASING). Any negative values indicate that the H is aligned prior to the segment to which it was calculated. The y axis represents the durations in seconds.

t-tests.

- *Stress* was found to be significant for both phrasing conditions:
 - genitive: $t(15.528)$, $df(57)$, $p < 0.001$
 - dative: $t(9.579)$, $df(59)$, $p < 0.001$.

In both phrasing conditions the alignment of the H was significantly closer to the end of the first postaccentual vowel when the stress was on the first syllable, than when it was on the second. This can be seen both in the table with the means, and in the interactions figure presented.

- *Phrasing* was only found to be significant for the condition where the stress was on the second syllable ($t(-3.089)$, $df(55)$, $p = 0.003$). This means that G2 was further away from the offset of the clitic than D2. This result is the opposite from what we anticipated.

There are two points that need further investigation:

1. the difference in the alignment of H between the two stress conditions.
2. the unexpected finding that D2 is aligned closer to the end of the clitic than G2.

As far as the first point is concerned, we anticipated that, given that in conditions G1 and D1 the stress is on the first syllable, it would provide the necessary time for the H to reach its position. On the other hand, the condition with the stress on the second syllable is closer to the boundary, which made us anticipate that it would affect the alignment of the H by placing earlier in time. This should explain the difference in the alignment of the H between the stress conditions.

One other reason that might be able to explain the difference between G1, D1 and G2, D2 might be the different segments that take part in the pitch bearing syllable for each condition. Given the fact that in the two conditions of stress the H was measured relatively to different segmental landmarks, it could have been that the different segments making up those syllables could have interfered with the alignment.

The alignment of H for G1 and D1 was measured with relevance to the onset of the clitic (C2 segmental landmark). The previous vowel (V1), which would be of influence for the alignment of the H, was in four out of the five minimal pairs an /i/, while in one pair it was an /o/ ¹.

On the other hand, for conditions G2 and D2, we measured the H with reference to the segmental landmark E, which means that C2 is the previous segment that would influence the alignment of the H. What we have segmented as C2, though, was not the /u/ of the /mu/, but the whole clitic. This will be a factor that will not allow us to directly compare between the two segments, i.e. /i/ and /u/. Our goal is to compare the durations of V1 and C2 and see whether they can account for the difference in the alignment of the H between the two stress conditions.

The duration of the /i/ in G1 was found to be approximately 32ms, while for D1 it was approximately 27ms. Our finding approximated somewhat that of Fourakis et al. (1999). They had found that the duration of the /i/ in fast speech was 36.43ms for

¹For a full list of the pairs used and the paragraphs they were used in, please refer to Appendix I. In order to see only the pairs used, see 2.1

the unstressed condition (our participants practically used a fast rate of speech and we are looking at unstressed vowels). Our /i/ is shorter than that of Fourakis et al. (1999) because in our analyses we included cases where the /i/ was barely audible due to coarticulation phenomena. This means that there are cases that interfere with this result by providing the shortest case possible.

Since we found that the durations obtained for the /i/ were similar to those of Fourakis et al. (1999), we assume that our duration measurements for the /u/ should also approximate those of Fourakis et al. (1999). For the /u/ in the fast tempo they had found that the unstressed /u/ was 40.39ms long. Fourakis et al. (1999) concluded that

“[u] was consistently longer than [i], by as much as 25%”.

Since we are looking at an unstressed /u/, we will consider that our /u/ should be somewhat around 40-41ms and that we should find a difference in the alignment of the H by at least 25% of the /i/ between the two conditions. This difference is translated to 8ms in our experiment. This difference is not even close to explaining the difference in alignment between the two stress conditions.

We can thus conclude that so far it doesn't seem like the difference in the alignment of the H is caused by differences in the segmental make-up. It is most probably due to the fact that in conditions G1 and D1 there is more time for the H to reach its position, than in G2 and D2, due to distance from possible boundary pressure.

The second point that was of interest regarding the alignment of the H was the difference between G2 and D2. Contrary to our predictions, D2 seemed to be aligned closer to the end of the clitic and not before the prosodic boundary. We will first investigate whether the duration of the clitic was responsible for the difference in the alignment. There was a difference in the duration of the /mu/ between the two conditions (130ms for genitive and 116ms for dative). This difference was 14ms, while the difference between the two alignments was 18ms. It seems, thus, that the duration of the clitic can explain this difference. This would lead us to think that there is no actual difference between the alignment of the H between those two conditions. A finding like that would suggest that the alignment of the H does not change under different conditions

Rise	Stress 1	Stress 2
Genitive	237	165
Dative	210	172

Table 3.8: The means in ms for the duration of the rise.

of prosodic boundary placement. In order to verify this we decided to investigate the behaviour of the duration of the rise.

3.2.2.3 Duration of the rise

We decided to investigate the duration of the rise due to the difference in the alignment of the H between conditions G2 and D2. Given the results that we have seen so far, we would formulate the following hypotheses regarding the duration of the rise:

1. longer duration for G1 and D1, than G2 and D2 given the fact that we found a significant difference in the alignment of the H for these conditions.
2. G2 significantly shorter than D2, again given the fact that we found this difference in the alignment of the H.

The measurement that we used to calculate the rise was subtracting the point in the time axis of the L from the point in the time axis of the H (Hpoint minus Lpoint). The mean duration of the rise for each of the four conditions can be found in table 3.8.

We ran a *two-way ANOVA* and the results that we got were the following:

- *Stress* is highly significant for the duration of the rise ($F(94.434)$, $df(1)$, $p < 0.001$).
- *Phrasing* was marginally not significant for the duration of the rise ($F(3.722)$, $df(1)$, $p = 0.060$).
- Finally, there was an interaction between the two factors ($F(7.793)$, $df(1)$, $p = 0.008$).

Figure 3.9 shows a plot of the two factors (STRESS*PHRASING).

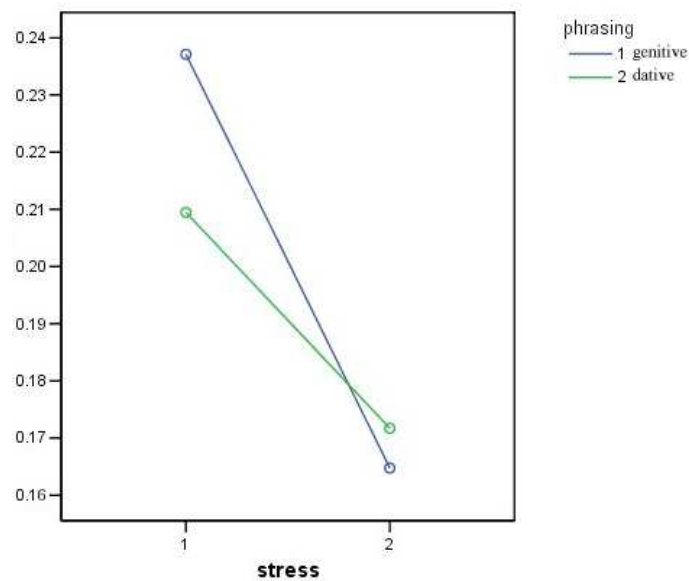


Figure 3.9: This figure shows the results for the duration of the rise for the *two-way ANOVA*, with STRESS*PHRASING.

The *paired-samples t-tests* reported the following:

- *Stress* was found to be significant for both phrasing conditions (genitive: $t(8.753)$, $df(57)$, $p < 0.001$, and dative: $t(5.222)$, $df(59)$, $p < 0.001$). This means that in both phrasing conditions, when the stress falls on the first syllable, the duration of the rise lasts significantly longer than when the stress falls on the second syllable. This reflects what we had anticipated.
- *Phrasing*, most importantly, was found to be highly significant for the conditions where the stress is on the first syllable ($t(3.683)$, $df(62)$, $p < 0.001$), while it was not found to be important for the conditions where the stress is on the second syllable ($t(-0.088)$, $df(55)$, $p = 0.931$). This means that, when the stress falls on the first syllable, the duration of the rise is significantly longer for the genitive than for the dative. Thus we did not find the difference between G2 and D2, as we anticipated.

There are three things that require an explanation as far as the duration of the rise is concerned:

1. the difference between conditions G1 and D1, according to which the rise is longer when the stress is on the first syllable and the phrasing is genitive, than when the stress is on the first syllable and the phrasing is dative,
2. the difference between the stress conditions. Conditions G1 and D1 are significantly longer than conditions G2 and D2,
3. the unexpected lack of difference between conditions G2 and D2.

Regarding the first point, we need to explain the significant difference between the duration of the rise for G1 and D1 (/to 'meli mu#/ vs. /to 'meli # mu/). The duration of the rise for G1 was 237ms, while 210ms for D1. This is a significant difference of 27ms.

One way to account for this is by investigating any durational differences between the segmental make-up. We shall remind the reader that we have found that C0, V0, C1 and V1 were significantly longer in G1 than in D1. This pattern had not appeared between the conditions G2 and D2. For the duration of the rise in G1, segments C0 and V0 are of special interest, while for condition D1 it is the segments C1 and V1 that mainly take part in the rise. We will compare the means of these segments and see whether the difference in the alignment of the two conditions can be attributed to different segmental make-up. The duration of C0 and V0 (the pitch bearing syllable) is 147.7ms, while the duration of C1 and V1 (the pitch-bearing syllable in condition D1) was 93.4ms. This is a difference of 54.3ms, which can easily explain the difference in the duration of the rise between G1 and D1.

The fact that we don't find the same durational difference in the alignment of the H between conditions G2 and D2 could also be explained by the fact that we don't have any durational differences in the segments for these two conditions. We will come back to this issue later.

It is interesting to ask ourselves why there needs to be a durational difference between conditions G1 and D1, while there is none between conditions G2 and D2. This might

be due to the fact that there is no pressure from an upcoming boundary in the cases with stress on the first syllable, while there is such pressure with the cases having stress on the second syllable. It is the same explanation that we gave for the fact that nouns in G1 were longer than in D1, while between G2 and D2 there was no significant difference.

The second point that we have mentioned is the difference in the duration of the rise between the stress conditions. We find the same effect as in the alignment of the H; that is, a significant difference between stress conditions. Both the alignment of the H and the duration of the rise show that the position of stress influences them. When stress is on the first syllable, H is aligned closer to the onset of the clitic and the duration of the rise is longer than when the stress is on the second syllable. Regarding the difference between G1 and G2, the durational difference of the syllable that takes part in the accent (C0+V0) between the two conditions was 14.2ms, while the difference of the duration of the rise was 72ms. Furthermore, regarding the difference due to segmental make-up between D1 and D2, the syllable taking part in the accent (C1+V1) was 5.7ms different between conditions, while the duration of the rise was 38ms longer in D1 than in D2. Thus, we are not able to explain why $G1 > D1$ and $G2 > D2$ based on segmental durations.

Since we were not able to explain this difference based on durational measurements of the segments between the two conditions, we are left with the explanation that in the condition with the stress on the first syllable there is more time for the rise to take place, which means that the duration of the rise lasts longer than when there is pressure by the forthcoming boundary, as there is in the case with the stress on the second syllable.

The third point we need to investigate is the lack of difference in the duration of the rise between conditions G2 and D2. This was surprising, given the fact that there was no difference between the alignment of the L for those two conditions, but there was a significant difference between the alignment of the H.

In order to see where the lack of variance in the duration lies (since we anticipated the duration of D2 to be longer than the duration of G2), we decided to calculate the distance of the H alignment from the beginning of the clitic as well (segmental landmark

H-C2	Stress 1	Stress 2
Genitive	-4.5	30.4
Dative	-12.8	39.8

Table 3.9: The means in ms for the alignment of the H with reference to C2 segmental landmark for all conditions.

C2, while up until now we were calculating it with reference to E). Since the alignment of the L was not big enough to cause a significant variation in the duration of the rise, we gather that the alignment of the H should be stable with regard to the onset of the clitic, given the fact that there is no difference between the durations of the segments, or between the duration of the rise, which is actually what we found. The alignment of the H lies 30.4ms from the onset of the clitic for the third condition, and 39.8ms from the onset of the clitic for the fourth condition. This is not a significant difference ($t(-1.567)$, $df(55)$, $p = 0.123$). This suggests that there is no actual difference in the alignment of the H between the two conditions (G2 and D2), as the analysis presented below will show.

Table 3.9 shows the mean alignment of the H, when it is measured with relation to the C2 segmental landmark for all conditions. Figure 3.10 shows the result of the *two-way ANOVA* on the alignment of the H. This test reported the following:

- *Stress* was significant for the alignment of the H ($F(87.335)$, $df(1)$, $p < 0.001$).
- *Phrasing* was not significant ($F < 1$).
- There was a marginally significant *interaction* ($F(4.123)$, $df(1)$, $p = 0.048$).

Follow-up *t-tests* were performed to indicate the source of the interaction:

- *Stress* was highly significant for both phrasing conditions (genitive: $t(-6.714)$, $df(57)$, $p < 0.001$, dative: $t(-7.514)$, $df(59)$, $p < 0.001$).
- *Phrasing* was not significant for any of the conditions. This is surprising since we did find a (marginal) interaction, but we suspect that it is due to small durational differences between the phrasing conditions, which cannot constitute a

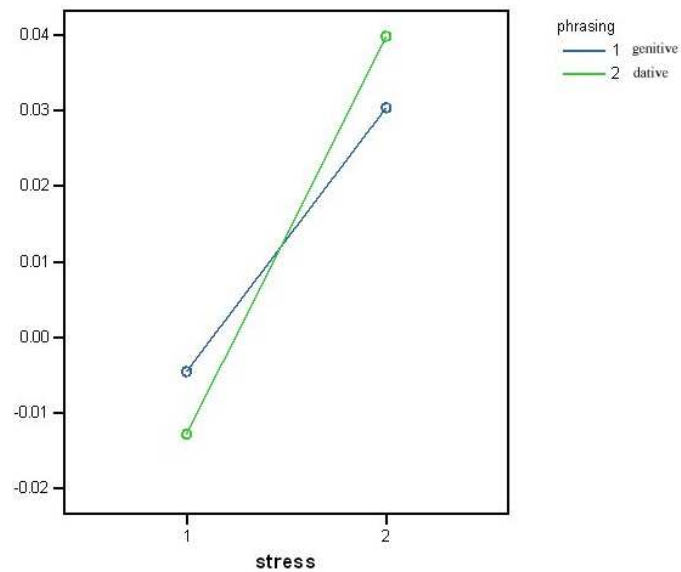


Figure 3.10: This figure shows the results for the alignment of the H for the *two-way ANOVA*, when H is measured with reference to C2 for all conditions (STRESS*PHRASING).

big enough sample for the phrasing to be considered as significant.

This means that the difference in the alignment of the H that we found between conditions G2 and D2 (when we measured it with reference the E segmental landmark) came from the fact that there is a difference in the duration of the /mu/ after the alignment of the H and not from a significant difference in the alignment of the H between the two conditions.

This finding has a very important implication. The alignment of the L and the H (and thus the duration of the rise) do not seem to differ between conditions G2 and D2. The only difference that we are establishing between the two conditions is that the clitic is significantly longer in condition G2 than in D2. We will discuss the implications of this finding later in the 4 section. Figure 3.11 presents the alignment of the H relative to C2 and E segmental landmarks for both phrasing conditions (G2 in the first table and D2 in the second). It is obvious that there is no difference in the duration of the rise and

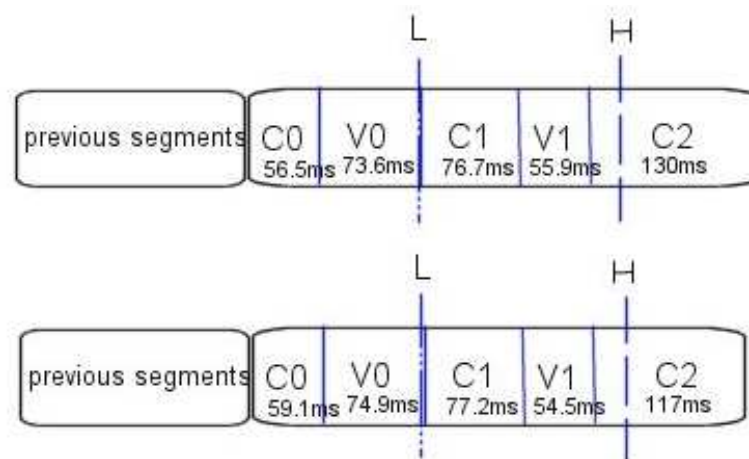


Figure 3.11: A figure that shows how the alignment of the H changes when we measure it with reference to C2, or E. This figure shows that it is the duration of the clitic that gave us the difference in the alignment of the H in the first place. The first table shows the alignments for condition G2 and the second for condition D2. We can see that when we compare the H with C2, the difference in the alignment is not that big than when we compare it to the E.

the alignment of the H, when measured with reference the C2 segmental point. There is, however, a difference in the alignment of the H when measured with reference to the segmental point E.

This finding should explain our initial puzzling result, where we didn't find a significant difference in the duration of the rise between G2 and D2, while we did find a significant difference in the alignment of the H between the same conditions. These results are consistent with the result that we found originally, according to which we could explain the difference in the alignment of the H between G2 and D2 by means of the duration of the clitic.

Finally, figure 3.12 represents the alignment of the L and H tones and the durations of all segments for conditions G1 and D1, like the figure for conditions G2 and D2. This is for the convenience of the reader, to be able to visualise the differences.

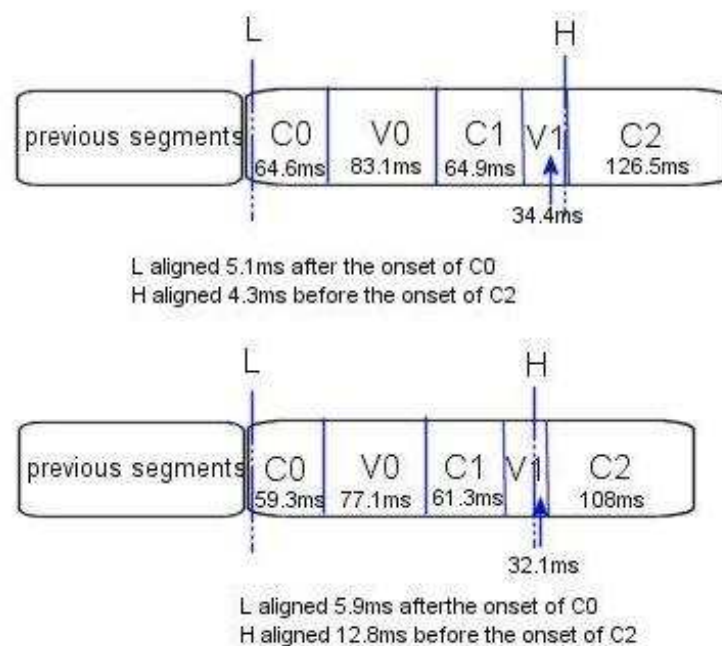


Figure 3.12: A figure that shows how the alignment of the edge tones and the durations of segments change between conditions G1 and D1. It is similar to the way we presented conditions G2 and D2, so that the reader will be able to visualise the differences. The first graph represents condition G1 and the second the condition D1.

Our analyses so far have given us the finding that the alignment of the H edge tone in a pitch accent is not influenced by the place of the prosodic boundary. Since our original hypothesis was not met, we thought that it would be interesting to investigate the alignment of the following L (the Low edge tone of the pitch accent immediately following the pitch accent we have been investigating). The slope of F_0 from the H to the following L might be an indicator of the different phrasing possibilities. By this we mean that perhaps the following L in condition D2 is placed closer to the H than in condition G2. This duration difference would also cause a difference in the slope between the H tone and the following L. Unfortunately, given the fact that originally in our experimental design we did not take into consideration the number of unaccented syllables following each prosodic word in each condition, it is impossible to compare between the four conditions the alignment of the following L. This question should

constitute a matter of further research.

3.2.3 Conclusions for the alignment of F_0 movements

In sum, the results that we got for the alignment of the Low and the High tones of the prenuclear pitch accent are the following.

The alignment of the Low tone seemed to be influenced by the existence of a word boundary; i.e. a left word-boundary effect seemed to prohibit the L from aligning in a “canonical” position, but it resumed its “canonical” alignment approximately 3-3.5ms before the onset of the accented syllable, when there was no such effect.

The alignment of the High tone on the other hand gave us very interesting results. First of all, it appears that the conditions with stress on the first syllable allow for a greater rise duration and a difference in the alignment of the H between stress conditions. In the case where the stress is on the first syllable, the duration of the rise is longer than when the stress is on the second, suggesting that the up-coming prosodic boundary does exercise a pressure on the alignment of the edge tones.

What was most surprising, though, was the finding that the prosodic boundary did not change the alignment of the H tone within stress conditions. That is, there was no difference between the alignment of the H for conditions G1 and D1 (the differences that we found were explained due to segmental durational differences), nor between conditions G2 and D2 (when we measured the alignment of the H with reference to C2 for all conditions). This finding suggests that the prosodic boundary placement is not signalled by a difference in the alignment of the High tone, something that goes against our expectations.

Chapter 4

Discussion

The goal of this paper was to present how phonetic cues, such as duration and alignment of F_0 , exhibit a non-straightforward behaviour under different conditions of prosodic boundary and lexical stress placement. The main assumption of this research was that these cues would show a different behaviour under the four conditions that our experiment created. We set out to investigate their exact behaviour under these conditions.

The results of our experiment are divided into two groups; the durations of the segments and the clitic, and the alignment of the L and H tones. We investigated how the duration of each segment of the noun and of the clitic changes under different placements of the prosodic boundary and under different proximity of the pitch accent to the prosodic boundary. We tried to see what kind of durational mechanisms could be operating on our prosodic words. Each mechanism provided us with some assumptions, the fulfilment of which would prove the operation of the mechanism in question. The durational mechanisms that could have been working in our data were those of *pre-boundary lengthening*, *polysyllabic shortening*, *articulatory strengthening* and *accentual lengthening*. Accentual lengthening could only be investigated in the case of the clitic and not directly on our nouns.

We need to draw the attention of the reader to the fact that we were working with

prosodic words, which means that our findings refer only to that domain. Moreover, we would like to point out that the durational mechanisms that we investigated have not been a matter of research for Greek to our knowledge.

Our results suggested that Greek does not seem to exhibit *prosodic word final lengthening*. Although the clitic was longer when it was before the boundary than when it was after it, we did not find the same effect for the duration of the second syllable of the noun when it was preceding a boundary. This is a finding that is in accord with other indirect cues mentioned in other papers for Greek (e.g. Arvaniti (2000); Botinis (1989)). We think that the reason why the genitive was longer than the dative is that the duration of the clitic is shortened when it affiliates as a proclitic, than when it affiliates as an enclitic.

Furthermore, we didn't find any evidence for *accentual lengthening* on the clitic, as the clitic closer to the pitch accent in the genitive was not longer than the one further away from it. In our experiment we assumed that if accentual lengthening operates in Greek, it will be attenuated by a word boundary (based on the finding of Turk and Shattuck-Hufnagel (2000) for English) and either attenuated or blocked by the existence of a prosodic word boundary. Based on these assumptions, Greek does not seem to exhibit accentual lengthening. We also found indirect evidence that *articulatory strengthening* does not operate in Greek, since the clitic was longer in the genitive than in the dative.

Finally, we investigated the existence of *polysyllabic shortening* in our data. This is also a mechanism that has not been investigated in Greek. We made the assumption that this mechanism can operate within the boundaries of a prosodic word, and based on that assumption we did not find support for its operation within a prosodic word in Greek.

We can see that from our experiment we did not find any of the durational mechanisms that have been found to work in languages such as English and Dutch. This difference in the way duration is manipulated by speakers might be deriving from the dichotomy between "syllable-timed" and "stress-timed" languages. As we mentioned before, Greek has been traditionally considered a "syllable-timed" language, while English (the language that has been most investigated and in which all the durational

mechanisms we investigated have been found to operate) is considered a “stress-timed” language.

The difference between these two types of languages was first based on the “isochrony” theory, but recently research on how speakers remedy clashes and lapses has helped towards that distinction. Arvaniti (1994) investigated the rhythmic structure of Greek by means of how Greek speakers resolve clashes and lapses and she concluded that “the rhythmic structure of syllable-timed languages is unlikely to be as regular as that of stress-timed ones due to lapse tolerance and the clash resolution strategies used” (Arvaniti, 1994, p. 266). Given this distinction, as presented, we think that there is much work to be done on the durations of Greek, before conclusions on how the durations of segments in experiments like ours would be expected to operate.

We would like to point out that our experiment was not setup to investigate these mechanisms. In particular the results regarding polysyllabic shortening, accentual lengthening and articulatory strengthening were based on arbitrary assumptions and need to be considered with caution.

In summary, it looks like the duration of the segments of the nouns is regulated both by stress position and by boundary position. The duration of the clitic seems to work towards signalling its syntactical affiliation by shortening the proclitic in comparison to the clitic. The durations of the nouns are also influenced by the position of the stress and of the boundary. When the stress is further away from the prosodic boundary, it seems as if the durational differences between possible phrasings are manifested, while when there is a prosodic boundary in the vicinity of the stressed syllable, then the segments do not have the time to express the different phrasing possibilities. This explains why segments with stress on the first syllable were longer than the ones with stress on the second, and why there was a difference in the duration of the segments between conditions of genitive and dative when stress was on the first syllable.

Regarding the results that we got for the alignment of the edge tones, our assumptions for the alignment of the Low tone were met. However, the analysis of the H alignment produced some highly interesting findings, which were not in accord with our original

assumptions.

The alignment of the L tone was not influenced by the position of the prosodic boundary of the prosodic word, but there was an effect of the position of the pitch accent. This was actually an effect of word boundary, according to which the L could not align outside the word boundary, when the pitch accent was on the first syllable of the word.

One of our hypotheses for the alignment of the H tone was confirmed. The alignment of the H and of the duration of the rise were influenced by the position of the stress. When the stress was further away from the prosodic boundary, the duration of the rise was longer (which is what we would expect, given that the duration of the segments taking part in that prosodic word were longer as well). This did not deviate from our expectations.

However, we expected that the alignment of the H would be influenced by the prosodic boundary, when the stress was on the second syllable, and this hypothesis was not confirmed. Our assumption was that an alignment that co-occurred with a prosodic boundary would have to decide whether to take the boundary into consideration or not. We assumed that a pitch accent further away from the boundary would not be as influenced.

Our findings suggest a different pattern. The alignment of the H occurred within the first postaccentual vowel, regardless of where the prosodic boundary was. That is, there was no difference in the alignment of the H between the following prosodic words:

/to 'meli mu#/ vs /to 'meli # mu/

and most surprisingly also no difference between:

/to me'li mu#/ vs /to me'li # mu/.

This finding was replicated by the investigation of the duration of the rise. The duration of the rise between conditions G1 and D1 and between G2 and D2 was found to be the same. This suggests that the alignment of the H in the pitch accent of prosodic words in Greek does not take into consideration the place of the prosodic boundary, but aligns either way with the first postaccentual vowel.

The aforementioned analysis led us to the conclusion that differences in the placement

of prosodic boundary in Greek prosodic words are not signalled by the alignment of the H of the pitch accents. This implies that the Low and High tones of prenuclear accents at prosodic words are not edge tones that signal the end of a prosodic domain.

This finding adds to the research presented so far in the field regarding the alignment of edge tones of prenuclear accents. As presented in the *Introduction*, researchers have been working on the factors that influence the alignment of those tones and have found that this alignment occurs with specific landmarks within the segmental string. Our findings suggest that, at least for Greek, the existence of a prosodic boundary does not influence the alignment of the H tone of prenuclear accents. Arvaniti et al. (1998) investigated the possibility that a word boundary might influence the alignment of the H, and although their results were not very clear-cut, they found that there were speakers who did take the boundary into consideration when aligning the H, while others didn't. The alignment of the H changed for one of their speakers if the accented syllable was not followed by two unstressed syllables belonging to the *same* word. Their general conclusion was that "the data suggest that the alignment of the H is largely unaffected by the position of the accent in the word" (Arvaniti et al., 1998, p. 21). They do consider however, that what constitutes "canonical" conditions, under which the alignment of the H can be investigated without any other factors interacting, is when there are at least two unstressed syllables following the stressed one and they preferably belong to the same word.

Our results add to this knowledge that the existence of a prosodic word boundary is not a factor that influences the alignment of the H. This means that it is no longer considered an "extreme" condition having a prosodic word boundary separating the alignment of the H from the accented syllable. We were not able to see how the number of following unstressed syllables might influence both the alignment of the H and of the following L, given that our experiment was not designed to investigate that. This should constitute a matter of further research.

Since we did not find a difference in the alignment of the H, it would be interesting to see how the listeners perceive the two syntactic affiliations of the clitic. Given that we found a shortening of the proclitic in comparison to the clitic, a perception experiment

would be able to show us whether or not manipulating the duration of the clitic would cause the listeners to distinguish between the two syntactic possibilities. A continuum of prosodic words with a clitic whose duration will vary from short to long will show whether the difference in the duration of /mu/ can actually cause a difference in the perception of the prosodic boundary for speakers.

In this paper we mentioned that we would like to investigate the possibility that the alignment of the Low following the High tone of the prenuclear accent might be a cue for the listener to distinguish between the two phrasing possibilities. A new production experiment is in order, where the number of unstressed syllables following the High tone will be controlled for.

Furthermore, we think that there is a possibility that the context following the prosodic word and the verb with the ambiguous syntactic structure will show the reader where the affiliation of the clitic is (thus where the prosodic boundary is placed). This can also be examined with the help of a perceptual test, where the reaction times of the listeners will be measured, while an increasing amount of information will be presented to them. A continuum of information provided to the listener (at the beginning only the prosodic word, then the beginning and the whole of the verb and finally the object of the verb) will allow us to see when the listener makes her decision with certainty regarding the affiliation of the clitic.

Given that we did not find a difference in the alignment of the H between conditions G2 and D2, we would also like to investigate whether the listeners perceptually find a difference between conditions G1 and D1 and also between G2 and D2. For that reason it would be interesting to run a perception test with prosodic words which have either been produced for one or the other syntactic affiliations and to see whether the listeners can perceive the difference, even though the alignment of the H does not help.

We would also like to point out the fact that there are more phonetic cues that might be of significance for the listener when distinguishing between conditions. As we already mentioned in our paper, we noticed the existence of a *connected speech process* between the noun and the clitic. Given the fact that the connected speech phenomenon occurred in both phrasing possibilities in our data, we thought that it is not a way for

the speaker to express different prosodic boundary placements. This point however, is not covered by our experiment and further investigation is in order. Furthermore, there are cues such as *amplitude* and *spectral balance* which need to be investigated, and which this research did not cover.

Regarding the analyses of duration, there is a whole field of the research on the duration of segments and mechanisms that regulate them which has presented several important findings for other languages. Research in Greek will be of vital significance for future studies. Most of our assumptions in this exploratory study have been arbitrary, given the fact that we have no background studies to base them on. This is a great shortcoming of research on Greek, which needs to be covered.

Finally, our research has proved that the prosodic word level in Greek does not seem to be signalled by a difference in the alignment of the H of the prenuclear pitch accent. This is a point that needs further investigation, since it constitutes an unexpected finding. Further production experiments need to take place for us to replicate this finding and to compare it with the way different prosodic levels of the prosodic hierarchy in Greek (and other languages, or dialects of Greek) are signalled.

Appendix A

Materials

The materials that we used constituted of five minimal pairs. Each pair was used in four different paragraphs. This gave us a total of twenty paragraphs. They are presented below, first the paragraph in Greek, as it was presented to the participants, and a translation in English.

Below we present the five minimal pairs used. Each bullet point represents one condition: G1, D1, G2 and D2 respectively.

1. First Pair: Μέλι-Μελί

The prosodic word used in this pair was: /to 'meli mu/ or /to me'li mu/

- Το μεγαλύτερο πρόβλημα που έχουν τα ντουλάπια της κουζίνας μου είναι ότι πιάνουν ζουζούνια. Υπάρχουν ιδιαίτερα κάποια τρόφιμα, στα οποία βρίσκω συνέχεια μαμουνάκια. Το μέλι μου είναι γεμάτο ζουζούνια. Κολάνε απέξω και πολλές φορές καταφέρνουν να μπουνε και μέσα.
- Η μητέρα μου συνηθίζει να ξυπνάει νωρίτερα από εμένα κάθε πρωί και μου φτιάχνει πρωινό. Επειδή της ίδιας της αρέσει το μέλι, θεωρεί ότι κι εγώ πρέπει να το τρώω. Αυτό όμως δεν συμβαίνει ποτέ. Το μέλι μου φέρνει αναγούλα το πρωί. Γι' αυτό και της έχω ζητήσει να μη μου φτιάχνει πρωινό.
- Πριν τρεις βδομάδες πήρα το ίδιο μπλουζάκι σε δύο χρώματα. Το ένα

ήταν πράσινο και το άλλο μελί. Το μελί μου είναι λερωμένο εδώ και μια εβδομάδα. Ακόμη δεν έχω βάλει πλυντήριο να το καθαρίσω. Έχω την αίσθηση ότι ο λεκές θα μείνει, αφού το άφησα τόσο καιρό.

- Το μελί είναι ένα χρώμα, το οποίο θεωρώ ότι μου ταιριάζει πολύ. Δεν μπορώ να πω ότι υπάρχουν γενικώς πολλά χρώματα που μου πηγαίνουν. Το μελί μου φωτίζει το πρόσωπο. Πηγαίνει με τα χρώματα του δέρματός μου και γι' αυτό συνηθίζω να το φοράω.

2. Second Pair: Ράφι-Ραφή

The prosodic word used in this pair was: /to 'rafi mu/ or /i ra'fi mu/

- Αυτό το χρόνο έχω την αίσθηση ότι είμαι η πιο βρώμικη από τις συγκατοίκους μου. Έχουμε μοιράσει τα ράφια μας και η καθεμία έχει πάρει από ένα. Το ράφι μου βγάζει πάντα την περισσότερη σκόνη. Φαίνεται ότι τα κορίτσια καθαρίζουν τα δικά τους πιο συχνά, απ' ότι εγώ το δικό μου.
- Στο σπίτι της μητέρας μου έχουνε βάλει ένα ράφι πολύ ψηλά, για να κρύβουν εκεί τα χρήματα και τις σοκολάτες. Αφού όμως κανείς δεν το φτάνει, είμαι υποχρεωμένη κάθε φορά να το καθαρίζω εγώ. Το ράφι μου βγάζει την ψυχή να το καθαρίσω. Μέχρι και σκάλα χρησιμοποιώ για να το φτάσω.
- Στο μάθημα της Χειρουργικής στην Ιατρική πρέπει να κάνουμε κάποιες ασκήσεις. Μία από αυτές είναι να διαγωνιστούμε για το ποιός θα κάνει την καλύτερη ραφή στον ασθενή. Η ραφή μου βγαίνει η καλύτερη στην τάξη. Οι καθηγητές λένε ότι δεν θα άφηνε σημάδι.
- Το παντελόνι που αγόρασα από το Παγκράτι δεν είναι καλό. Εκτός από το ότι το κουμπί του έφυγε αμέσως, έχει κι άλλα προβλήματα. Η ραφή μου δημιουργεί πληγή στην κοιλιά. Εξέχει λίγο το φερμουάρ και με τσιμπάει. Είναι εξαιρετικά ενοχλητικό.

3. Third Pair: 2. Λάδι-Λαδί

The prosodic word used in this pair was: /to 'ladi mu/ or /to la'di mu/

- Η οικογένειά μου ασχολείται με την παραγωγή λαδιού εδώ και πολλές γενιές. Εγώ είμαι ο τελευταίος της γενιάς, που ασχολείται με την επιχείρηση. Θεωρώ ότι με τα χρόνια προσφέρω όλο και καλύτερο λάδι. Το λάδι μου φημίζεται για την καθαρότητά του. Εχουν να το λένε όλοι στο χωρίο.
- Παρόλο που κατάγομαι από την Ελλάδα, δεν έχω συνηθίσει να τρώω λάδι. Είναι ένα συστατικό που χρησιμοποιείται πολύ στην μεσογειακή κουζίνα, αλλά εγώ δεν το αντέχω. Το λάδι μου χαλάει την γεύση του φαγητού. Μου δίνει την εντύπωση ότι το φαγητό γίνεται πολύ βαρύ.
- Κάθε δύο χρόνια κανονίζουμε μια συνάντηση με τις παλιές μου συμμαθήτριες. Συνεγνωστούμαστε να φορέσουμε ένα από τα δύο μπλουζάκια, που πήραμε στην αποφοίτησή μας. Σήμερα με πήραν τηλέφωνο και μου είπαν ότι θα βρεθούμε αύριο και θα πρέπει να φορέσουμε το λαδί. Το λαδί μου είναι όμως για πλύσιμο. Δεν θα προλάβω να το πλύνω και να το στεγνώσω μέχρι τότε.
- Τα Χριστούγεννα οι καλύτεροί μου φίλοι μου έφεραν για δώρο δύο πήλινα βατραχάκια. Ήταν ένα λαδί και ένα κίτρινο. Δυστυχώς όμως δεν μπορώ να τα κρατήσω πάνω στο τραπέζι. Το λαδί μου χαράζει το ξύλο του τραπεζιού. Ήταν ελαττωματικό από κάτω και δεν μπορώ να το ακουμπάω σε ευπαθή υλικά.

4. Fourth Pair: 5. Ρόλο-Ρολό

The prosodic word used in this pair was: /sto 'rolo mu/ or /to ro'lo mu/

- Στα δοκιμαστικά στο θέατρο πήραμε μέρος εγώ και η καλύτερή μου φίλη, η Μαρία. Εγώ έκανα δοκιμαστικό για τον πρωταγωνιστικό ρόλο, τον οποίο και πήρα. Το ρόλο μου ζητούσε να τον πάρει και η Μαρία. Ευτυχώς δεν θύμωσε όταν έμαθε τα αποτελέσματα.
- Ένας φίλος σκηνοθέτης μου ζήτησε να πάρω μέρος σε μια παράσταση, χωρίς όμως να πληρώνομαι, καθώς δεν είχε οικονομική υποστήριξη. Εγώ δέχτηκα χωρίς να διαβάσω το ρόλο. Δεν ήξερα όμως τι παράλογες απαιτή-

σεις είχε. Στο ρολό μου ζητούσε να εμφανιστώ χωρίς ρούχα. Όταν το έμαθα αυτό αρνήθηκα να συνεχίσω.

- Στη σχολική παράσταση της χρονιάς τα παιδιά μου έπρεπε να παρουσιάσουν ένα φαγητό, το οποίο φτιάχνουμε στο σπίτι. Εγώ πετυχαίνω το ρολό μπιφτέκι, γιατί βάζω μέσα πολλά μπαχαρικά. Το ρολό μου άρεσε πολύ στη γιορτή. Ολοι αποφάσισαν να δοκιμάσουν τη συνταγή.
- Τις προάλλες αποφασίσαμε με τον άντρα μου να βάψουμε το σπίτι μόνοι μας. Αγόρασα λοιπόν ένα πινέλο και ένα ρολό για το βάψιμο. Το ρολό μου άρεσε πιο πολύ από το πινέλο. Δεν πιτσιλούσε καθόλου τη μπογιά και έβαφε πιο ομοιόμορφα.

5. Fifth Pair: Φίλη-Φυλή

The prosodic word used in this pair was: /i 'fili mu/ or /to fi'li mu/

- Έχω μια φίλη, η οποία έχει ζήσει στην Σουηδία για πολλά χρόνια και έχει πάρει κάποιες από τις συνήθειές τους. Η φίλη μου βγάζει τα παπούτσια της μέσα στο σπίτι. Ακόμη και σε σπίτια ξένων θα βγάλει τα παπούτσια της με το που θα μπει μέσα. Αυτό είναι μια συνήθεια, που δεν την έχουμε στην Ελλάδα.
- Δουλεύω σε μια διαφημιστική εταιρεία. Τον τελευταίο καιρό έχω παρουσιάσει κάποιες πολύ καλές ιδέες. Με αυτές τις ιδέες κατάφερα επίσης να προσελκύσω και άλλους πελάτες, ένας εκ των οποίων είναι μια μεγάλη διεθνής εταιρεία. Οι φίλοι μου βγάζουν το καπέλο στην δουλειά. Με παραδέχτηκαν ότι έχω πολύ καλές ιδέες.
- Όταν πηγαίνουμε για διακοπές στο εξοχικό μας, τα παιδιά της γειτονιάς χωρίζονται σε δύο φυλές για παιχνίδι. Βάζουν εμένα αρχηγό της μιας φυλής και τον άντρα μου αρχηγό της άλλης. Η κάθε φυλή αποφασίζει να κάνει μια καλή πράξη κάθε εβδομάδα. Η φυλή μου βγάζει τα ξερά χόρτα από την αυλή μας. Την άλλη βδομάδα θα ξεχορταριάσουν τις αυλές της υπόλοιπης γειτονιάς.

- Πριν από ένα χρόνο χωρίσαμε με τον άντρα μου, ενώ εγώ ακόμη τον αγαπούσα. Για κακή μου τύχη τους τελευταίους έξι μήνες πήρε μετάθεση στο τμήμα μου. Κάθε πρωί έρχεται και με χαιρετάει και με φιλάει στο μάγουλο. Το φιλί μου βγάζει στην επιφάνεια όλα τα κρυμμένα συναισθήματα. Δεν νομίζω ότι θα αντέξω για πολύ καιρό ακόμη.

We also used five filler paragraphs, which are the following:

1. First Filler:

Το χωριό μου έχει ως κύρια παραγωγή το λάδι. Το λάδι του είναι το προϊόν που αποφέρει τα περισσότερα χρήματα. Αν δεν είχαν την παραγωγή του λαδιού, οι κάτοικοι θα είχαν σοβαρό οικονομικό πρόβλημα και το χωριό θα μαράζωνε.

2. Second Filler:

Ο αγαπημένος μου ηθοποιός αποφάσισε πριν έξι μήνες να αναλάβει έναν πολύ απαιτητικό ρόλο προκειμένου να αποδείξει στον εαυτό του ότι είναι σε θέση να τον υποδυθεί. Η παράσταση ανέβηκε πριν μια βδομάδα και ήταν μια επιτυχία. Στο ρόλο του αποδείχθηκε καλύτερος από ποτέ. Κατάφερε και έκλεισε τα στόματα όλων όσων τον κακολογούσαν ότι ήταν επιφανειακός ηθοποιός.

3. Third Filler:

Στην βιβλιοθήκη έχουν προσλάβει ένα παιδί με διανοητική καθυστέρηση. Αρχικά του ανέθεσαν ένα ράφι για να δουν αν θα τα καταφέρει. Το ράφι του είναι πάντα το πιο τακτοποιημένο από όλα. Έχει δείξει μεγάλο ζήλο και ικανότητες. Γι' αυτό και τώρα θα του αναθέσουν ολόκληρο τμήμα. Είναι ευχάριστο να βλέπεις τέτοιες κινήσεις από υπεύθυνους φορείς.

4. Fourth Filler:

Πριν δύο χρόνια ένας κύριος άνοιξε ένα μαγαζί πλάι στο δικό μας, που πουλάει

μέλι. Το κακό είναι ότι και εμείς έχουμε ως κύριο προϊόν του μαγαζιού μας το μέλι. Ο ανταγωνισμός ήταν μεγάλος. Δεν στεναχωρηθήκαμε πολύ όταν το υγειονομικό έκλεισε το μαγαζί του. Το μέλι του βρέθηκε να είναι επίφοβο για την υγεία. Ετσι είμαστε πάλι μόνοι μας στην αγορά.

5. Fifth Filler:

Όταν γυρνάω στην Ελλάδα έρχεται πάντα το αγόρι μου στο αεροδρόμιο να με υποδεχτεί. Το πρώτο πράγμα που θα κάνει πάντα είναι να με φιλήσει. Το φιλί του μου θυμίζει το καλωσόρισμα. Νομίζω ότι ποτέ δεν θα ξεχάσω αυτήν την αίσθηση.

Appendix B

Instructions to participants

The Instructions that we gave to the participants were the following (translated in English, since the original text was in Greek):

First slide:

During this experiment you are asked to read 75 paragraphs. Each paragraph is 4-6 sentences long and is written in Greek. Each paragraph appears in a new powerpoint slide. Before you read the paragraph you are allowed to scan through it. After you finish reading the paragraph in front of you, click the mouse for the next slide with the next paragraph to appear.

Follow the same procedure until you reach at the end of the experiment. Try to follow the storyline of the paragraphs without getting distracted. In case you make a mistake, say the last sentence again.

Read as you would normally do. Don't be in a hurry and don't speak slower than your normal pace. There are many paragraphs, so if you need a break in between, don't hesitate to take one. I have placed a break in the middle of the Powerpoint presentation, just in case.

Many paragraphs are repeated, so don't hesitate to read them as many times they appear.

Second Slide:

Thank you very much for your help. Press the mouse whenever you are ready to start with the experiment. The next slide will contain the first paragraph that you need to read.

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